Ontario

Air Quality

IN ONTARIO

A concise report
on the state of
air quality in the
province of
Ontario

1998

Acknowledgments

This report has been prepared by the staff of the Environmental Monitoring and Reporting Branch of the Ministry of the Environment with contributions by the staff of the regional offices of the Operations Division and Laboratory Services Branch. Canada's National Air Pollutant Surveillance program is also acknowledged.

This report documents the continuation of major improvements in the province's air since 1971.

Preface

THE AIR QUALITY IN ONTARIO 1998 REPORT documents the continuation of major improvements in the province's air since 1971. This is a remarkable accomplishment in light of sharp increases in Ontario's population, economic activity and vehicular traffic during the past three decades. It is the job of the Ministry of the Environment, however, to look beyond the good news to find new ways to make greater environmental improvements.

While significant reductions were made between 1989 and 1998 for a number of key airborne contaminants – such as total reduced sulphur compounds, carbon monoxide, sulphur dioxide and nitrogen dioxide – air pollution still impacts the health and well-being of Ontarians.

Smog continues to be of particular concern. As in previous years, ground-level ozone and inhalable particles – the major components of smog – were the pollutants that most often exceeded the provincial ambient air quality criteria in 1998.

The Ontario government is taking strong action to protect and improve air quality on a number of fronts, with partners from all sectors of society.

Drive Clean, the province's program to reduce smog-causing emissions from Ontario's number one domestic source - cars, trucks and buses - is producing impressive results. Some 2.5 million light-duty vehicles had been tested as of March, 2001, with almost 86 per cent passing on first try. Repairs mandated by Drive Clean during its first year led to a 6.7 per cent reduction in smog-related emissions from light-duty vehicles in program areas, as well as an 18,500-tonne reduction in emissions of carbon dioxide, a contributor to global climate change.

Heavy-duty trucks and buses, an important source of microscopic dust particles that can infiltrate the lungs and aggravate respiratory problems, are being tested province-wide. When fully implemented in 2004, the Drive Clean program is expected to cover 5 million light-duty vehicles in southern Ontario and 200,000 heavy-duty trucks and buses across the province.

Drive Clean is complemented by several Ministry of the Environment initiatives, including the Smog Patrol, which targets the most grossly-polluting vehicles on Ontario roadways.

These efforts are an integral part of Ontario's Anti-Smog Action Plan (ASAP), through which a broad spectrum of industries and groups are committed to implementing

Ontario announced tough new actions to protect provincial air quality

voluntary actions that will reduce airborne pollutants and improve air quality. Actions have already been taken, or are planned, to achieve well over half of ASAP's goal of a 45 per cent reduction in smog-causing emissions by 2015, based on 1990 emission levels.

On January 24, 2000, Ontario announced tough new actions to protect provincial air quality, including mandatory tracking and reporting of all harmful air emissions by industrial and commercial emitters, and tough new emissions limits for smog and acid rain-causing pollutants.

Effective May 1, 2000, all power generators in the province were required to monitor and report on emissions of some 28 substances of concern. These include sulphur dioxide, nitrogen oxides and carbon dioxide.

A draft monitoring and reporting regulation extending to other industrial and institutional sectors has been released and the final regulation is expected to take effect in the near future.

Complementing mandatory reporting, the ministry has proposed tough new regulated emission caps for two harmful air pollutants. The proposed standards will cap total annual emissions of nitrogen oxides and sulphur dioxide from coal and oil-fired electricity generating stations. The standards will be implemented for the province's electricity sector, and will be later expanded to cover emitters in other major economic sectors of the province.

These emission caps will be constantly under review and scrutiny. Environmental protection is an ongoing process and must be guided by good science. The information collected through monitoring and reporting regulations will provide information for the setting of future caps, as well as a solid foundation for future air quality protection measures.

The ministry has invested more than $4 million since 1995 to develop one of the most modern and best-equipped air monitoring networks in North America. In May 2000, the new Air Quality Ontario initiative was established to give people greater access to timely information about the state of their air. Air quality information is now being provided for 28 communities across Ontario, including 10 additional communities, mostly in rural southwestern Ontario and high-growth areas in the Greater Toronto Area.

During peak smog season (May 1 to September 30), people may now receive early, comprehensive information about current and forecast air quality, putting them in a better position to take appropriate action on bad air days.

Air quality reports are provided as often as six times daily (during smog advisory days), seven days a week during smog season. Up to three days notice is given when poor air quality is predicted. Air Quality Index and Smog Alert information is available through a ministry Web site (www.airqualityontario.com). Smog Advisories are also available by e-mail for subscribers to the ministry's smog alert network.

While the Ontario government is taking action at home to fight air pollution, emissions from the U.S. account for a large percentage of our air quality problems.

One gratifying success came in March 2001, when the U.S. Supreme Court decided in favor of the U.S. Environmental Protection Agency in its effort to require significant reductions in emissions of smog-causing nitrogen oxides by many states. Ontario used its intervenor status in the case to support the agency.

The Ontario government will continue to look for new ways to build on an already strong record of action on behalf of the province's air, water and land.

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Air quality in Ontario continued to improve between 1989 and 1998.

1998 Highlights

- Air quality in Ontario continued to improve between 1989 and 1998. Levels of total reduced sulphur compounds decreased by 30 per cent in that period, carbon monoxide by 25 per cent, sulphur dioxide by 18 per cent and nitrogen dioxide by 11 per cent.
- These improvements in air quality were made despite increases in Ontario's population, economic activity and vehicular travel during the same period.
- In 1998, Ontario's Air Quality Index reported good to very good air quality readings more than 93 per cent of the time.
- Three air quality advisories were called in 1998, covering a total of eight days.
- On an international basis, using the most recent available data, Toronto's air was better than that in most of the cities with which it was compared, including New York, Chicago and Detroit.
- Ground-level ozone and inhalable particles – the major components of smog – were the pollutants that most often exceeded the provincial ambient air quality criteria. More than 50 per cent of the ozone and a considerable amount of fine particles were caused by air pollution from the U.S.
- Seasonal ozone means have shown increases since 1980. These increases occurred primarily in the 1980s and ranged from 0.5 to 0.7 per cent per year during the summer and winter periods, respectively.
- A winter fine particle episode was documented for the first time during February 1998 as a result of a new real time fine particle monitoring network.

Since 1971, the Ontario Ministry of the Environment has been monitoring air quality in Ontario.

Introduction

SINCE 1971, the Ontario Ministry of the Environment has been monitoring air quality in Ontario and using this information to:

- inform the public in real time about outdoor air quality;
- provide air quality advisories for public health protection;
- assess Ontario's air quality and evaluate trends;
- identify areas where criteria are exceeded and identify the origins of pollutants;
- provide the basis for air policy development;
- provide quantitative measurements to enable abatement of specific pollutant sources;
- determine the levels of pollutants from U.S. sources and their effects on Ontario;
- provide air quality researchers with data linking environmental and human health effects to air quality.

Air quality is measured on the basis of emissions of contaminants into the atmosphere from both human and natural activity, and from their atmospheric interactions. Local air quality is influenced by emissions from motor vehicles and other transportation sources, industrial sources, and meteorological and topographical conditions.

Distant U.S. sources are significant contributors to local air quality for contaminants that undergo long-range transport and transformation, such as ozone, fine particles, trace metals, toxics and the components of acid rain.

Table 1.1 shows the relationship between monitored air pollutants and current air issues. Individual contaminants can have impacts (usually adverse but sometimes beneficial) on a number of air issues at the same time. Such interactions require integration of air issues in order to see the complete picture.

This report, 28th in a series, summarizes the state of ambient air quality in Ontario in 1998. It covers measured levels of ozone (O_3), particles and other criteria contaminants such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and total reduced sulphur (TRS) compounds. In addition, the report summarizes the 1998 Air Quality Index statistics from the real-time air quality index information system, examines regional smog episodes and provides an international perspective on air quality.

Once again, the focus of this year's publication is to report on the state of ambient air quality. The source monitoring statistics, as in the past, will be presented in a separate appendix document, along with the ambient data.

Increased emphasis is now being directed to ozone and inhalable (PM_{10}) and respirable ($PM_{2.5}$) particles, for which scientific evidence suggests significant impacts on health.

Ontario continues to benefit from one of the most comprehensive air monitoring systems in North America.

Ontario continues to benefit from one of the most comprehensive air monitoring systems in North America. The network is designed to measure air quality at more than 200 sites across the province and undergoes ongoing maintenance to ensure a high standard of quality control. Continuous real-time air quality data are reviewed, assessed and validated constantly. Action is taken immediately to correct anything that may affect the validity of the data. These measures ensure that the ambient air monitoring data are valid, complete, comparable, representative and accurate. As a result, for 1998 the network had 93.0 per cent valid data out of approximately four million data points. With this data, Ontario can make informed decisions about what needs to be done to protect our environment and improve our air quality.

	Smog	Global Warming	Urban Air Quality	Acid Deposition	Toxics	Aesthetics
Ozone	yes	yes	yes	yes	yes	
Sulphur Dioxide	yes	yes	yes	yes	yes	yes
Carbon Monoxide			yes		yes	
Oxides of Nitrogen	yes	yes	yes	yes	yes	yes
Volatile Organic Compounds	yes	yes	yes		yes	yes
Toxics			yes		yes	
Particles	yes	yes	yes	yes	yes	yes
Total Reduced Sulphur Compounds			yes		yes	yes

Table 1.1

Linkages Between Air Pollutants and Air Issues

The AAQCs are used as yardsticks for measuring the success of our programs.

Overview of Principal Contaminants

CHAPTER 1

THE PRINCIPAL CONTAMINANTS considered in this report include O_3, PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and TRS compounds. They are also commonly referred to as criteria pollutants because Ontario has established ambient air quality criteria (AAQC) based on health and/or environmental effects. The AAQCs are used as yardsticks for measuring the success of our programs. Most of the trend information presented in subsequent chapters of this report is based on two types of data: direct measurement of ambient air concentrations and estimates of air emissions based on best available information.

A brief description of the criteria pollutants according to their characteristics, sources and effects is provided below and summarized in Table 1.1 along with the current Ontario ambient air quality criteria.

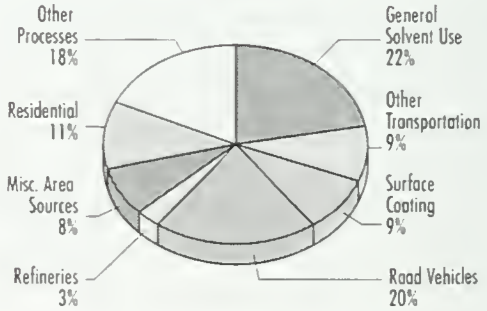


Figure 1.1
Ontario VOC Emissions by Sectors
(Emissions from Human Activity, 1998 Estimates)

Ground-level ozone

Characteristics: O_3 is a colourless, odourless gas at ambient concentrations, and is a major component of smog.

Sources: Ground-level ozone is not emitted directly into the atmosphere. It results from chemical reactions between volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. High levels typically occur from May to September, between noon and early evening. Figure 1.1 shows estimates of Ontario's VOC emissions caused by human activity, by sector. Transportation modes account for approximately 29 per cent of VOC

CLEAN AIR TIP

Reduce car use all year round: walk, cycle, take public transit or car pool.

emissions. Owing to the large forested area in Northern Ontario, biogenic emissions of certain VOCs are significant – approximately three times those from sources caused by human activity. The sources of NO_x are in the nitrogen dioxide section below.

Effects: O_3 irritates the respiratory tract and eyes. Exposure to high levels of O_3 results in chest tightness, coughing and wheezing. People with respiratory and heart problems are at a higher risk. Ozone has been linked to increased hospital admissions and premature death. Ozone causes agricultural crop loss each year in Ontario and noticeable leaf damage in many crops, garden plants and trees. A recent federal/provincial scientific assessment document indicates that health effects attributable to ozone are occurring at much lower ozone levels than was thought in the past. This new evidence will be reviewed and used in the process to develop new Canada-wide standards for ground-level ozone that will ulti-

> People with respiratory and heart problems are at a higher risk to the effects of ozone.

Table 1.2
Overview of Criteria Pollutants

Pollutant	Characteristics	Sources	Ontario Criteria	General Health Effects	General Ecological Effects
Ozone (O_3)	A colourless gas. Major component of summer smog.	Ozone is not emitted directly into the atmosphere. It is produced by photochemical action of nitrogen oxides and volatile organic compounds.	1 h average 80 ppb	Irritation of the lungs and difficulty in breathing. Exposure to high concentrations can result in chest tightness, coughing and wheezing.	Damage to agricultural crops, ornamentals, forests and natural vegetation.
Total Suspended Particles (TSP)	Particles of solid or liquid matter that stay suspended in air in the form of dust, mist, aerosols, smoke, fume, soot, etc. Size range 0.1-100 microns.	Industrial processes including combustion, incineration, construction, metal smelting, etc. Also motor vehicle exhaust and road dust. Natural sources such as forest fires, ocean spray and volcanic activity.	24 h average 120 µg/m^3 1 y average 60 µg/m^3	The smaller the particle the greater the effect on health. Significant effects for people with lung disease, asthma and bronchitis. See PM_{10} below.	Damage to vegetation, deterioration in visibility and contamination of soil.
Inhalable Particles (PM_{10})	Same as TSP except size range of particles is less than 10 microns.	Same as TSP.	24 h average 50 µg/m^3	Increased hospital admissions and premature deaths.	Same as TSP.
Total Reduced Sulphur (TRS)	Offensive odours similar to rotten eggs or cabbage.	Industrial sources include steel industry, pulp and paper mills and refineries. Natural sources include swamps and marshes.	1 h average 27 ppb (kraft pulp mill)	Not normally considered a health hazard. They are the primary cause of odours.	
Sulphur Dioxide (SO_2)	Colourless gas with a strong odour similar to burnt matches.	Electric utilities and non-ferrous smelters . Also primary metal processing, iron ore smelters, pulp and paper, petroleum refineries, etc.	1 h average 250 ppb 24 h average 100 ppb 1 y average 20 ppb	Breathing discomfort, respiratory illness, aggravation of existing respiratory and cardiovascular disease. People with asthma, chronic lung or heart disease are most sensitive to SO_2.	Leads to acid deposition, which causes lake acidification, corrosion and haze. Damage to tree leaves and crops.
Nitrogen Dioxide (NO_2)	Gas with a pungent and irritating odour.	Automobiles, thermal power plants, incineration, etc. Natural sources include lightning and soil bacteria.	1 h average 200 ppb 24 h average 100 ppb	Increasing sensitivity for people with asthma and bronchitis.	Leads to acid deposition: adverse effect on vegetation.
Carbon Monoxide (CO)	Colourless, odourless, tasteless and poisonous gas.	Major source is transportation sector; i.e., road vehicles, aircraft and railways.	1 h average 30 ppm 8 h average 13 ppm	Impairment of visual perception, work capacity, learning ability and performance of complex tasks.	

Particles affect people's health as well as causing corrosion, soiling, damage to vegetation and reductions in visibility.

mately lead to better protection of people's health and the reduction of ozone levels in Ontario.

Particles

Characteristics: Particles in the atmosphere consist of either solid particles or fine liquid droplets. They include aerosols, smoke, fumes, dust, fly ash and pollen. Composition varies with place and season. Particles in the atmosphere have been characterized according to size mainly because of the different health effects from particles of different diameters. Particles less than 10 microns and 2.5 microns in diameter are defined as inhalable particles (PM_{10}) and respirable particles ($PM_{2.5}$), respectively. The smaller the particle size the further the particle will penetrate into the lungs.

Sources: PM_{10} particles are emitted from industrial sources such as fuel combustion, energy production, incineration, construction, mining, metal smelting and processing (Figure 1.2). In the urban airshed, motor vehicle exhaust, residential wood combustion and road dust are the major sources. Natural sources include wind-blown soil, forest fires, ocean spray and volcanic activity. $PM_{2.5}$ material is primarily formed from chemical reactions in the atmosphere and through combustion.

Effects: The greatest effect on health is from particles 10 microns or less in diameter, which can aggravate bronchitis, asthma and other respiratory diseases. People with asthma or cardiovascular or lung disease, as well as children and elderly people, are considered to be the most sensitive to the effects of particles. Particles are also responsible for corrosion, soiling, damage to vegetation and reductions in visibility.

Figure 1.2

Ontario PM_{10} Emissions by Sectors

(Emissions from Area/Point/Mobile Sources, 1995 Estimates)

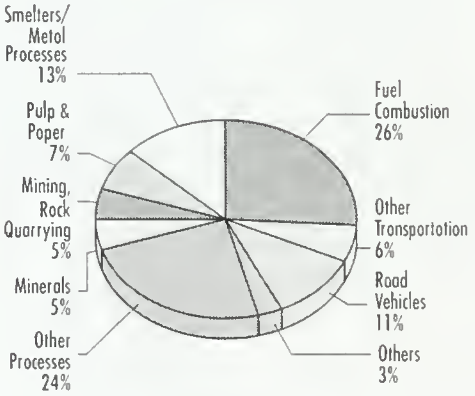
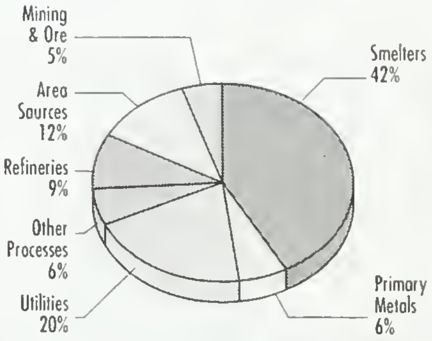


Figure 1.3

Ontario Sulphur Dioxide Emissions by Sectors

(Emissions from Human Activity, 1998 Estimates)



Sulphur dioxide (SO_2)

Characteristics: SO_2 is a colourless gas that smells like burnt matches. It can be oxidized to sulphur trioxide, which in the presence of water vapour is readily transformed to sulphuric acid mist. SO_2 can also be oxidized to form acid aerosols. SO_2 is a precursor to sulphates, which are one of the main components of respirable particles in the atmosphere.

Sources: Approximately 62 per cent of the SO_2 emitted in Ontario in 1998 came from smelters and utilities. Other industrial sources include iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources include residential, commercial and industrial space heating (Figure 1.3).

Effects: Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2 and NO_x are the main precursors of acid rain, which contributes to the acidification of lakes and streams, accelerated corrosion of buildings, and reduced visibility. SO_2 also causes formation of microscopic acid aerosols, which have serious health implications and contribute to climate change.

All combustion in air produces oxides of nitrogen.

Nitrogen dioxide (NO_2)

Characteristics: NO_2 is a reddish-brown gas with a pungent and irritating odour. It transforms in the air to form gaseous nitric acid and toxic organic nitrates. NO_2 also plays a major role in atmospheric reactions that produce ground-level ozone, a major component of smog. It is also a precursor to nitrates, which contribute to increased respirable particle levels in the atmosphere.

Sources: All combustion in air produces oxides of nitrogen (NO_x), of which NO_2 is a major component. Approximately 63 per cent of NO_x comes from the transportation sector in Ontario (Figure 1.4). A large part of the remaining 37 per cent comes from power generation, primary metal production and incineration. Natural sources of NO_x include lightning and the aerobic activity of soil bacteria.

Effects: NO_2 can irritate the lungs and lower resistance to respiratory infection. People with asthma and bronchitis have increased sensitivity. NO_2 chemically transforms into nitric acid and, when deposited, contributes to lake acidification. Nitric acid can also corrode metals, fade fabrics, degrade rubber, and damage trees and crops.

Carbon monoxide (CO)

Characteristics: CO is a colourless, odourless, tasteless and poisonous gas produced primarily by incomplete burning of fossil fuels.

Sources: The transportation sector accounts for 68 per cent of all CO emissions from human activity in Ontario (Figure 1.5). A large part of the remainder comes from primary metal producers (22 per cent) and from fuel combustion in space heating and industrial processes (5 per cent).

Effects: CO enters the bloodstream and reduces oxygen delivery to the organs and tissues. People with heart disease are particularly sensitive. Exposure to high levels is linked with the impairment of vision, work capacity, learning ability and performance of difficult tasks.

Total reduced sulphur (TRS) compounds

Characteristics: TRS compounds produce an offensive odour similar to rotten eggs or cabbage.

Sources: Industrial sources of TRS compounds include the steel industry, pulp and paper mills, refineries and sewage treatment facilities. Natural sources include swamps, bogs and marshes.

Effects: TRS compounds are not normally considered a health hazard except at very high concentrations. They are, however, a primary cause of odours.

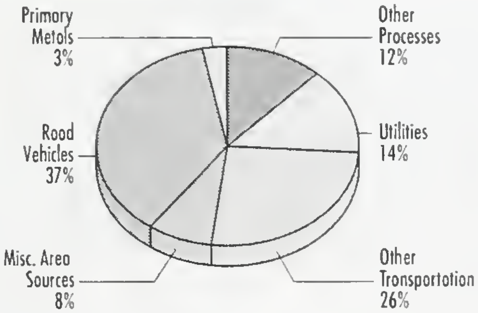


Figure 1.4

Ontario Nitrogen Oxides Emissions by Sectors

(Emissions from Human Activity, 1998 Estimates)

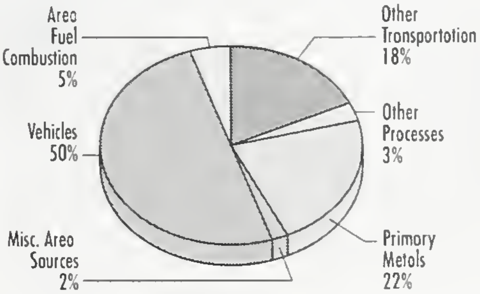


Figure 1.5

Ontario Carbon Monoxide Emissions by Sectors

(Emissions from Human Activity, 1998 Estimates)

More than 50% of Ontario's ground-level ozone can be attributed to trans-boundary pollution from the U.S.

Ozone in Ontario

CHAPTER 2

GROUND-LEVEL OZONE is a gas formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight. Ground-level ozone is the primary component of smog and is different from the ozone layer high above the earth that protects us from the sun's harmful UV rays. The formation and transport of ozone are strongly dependent on meteorological conditions. In Ontario, elevated concentrations of ground-level ozone are generally recorded on hot, sunny days from May to September between noon and early evening.

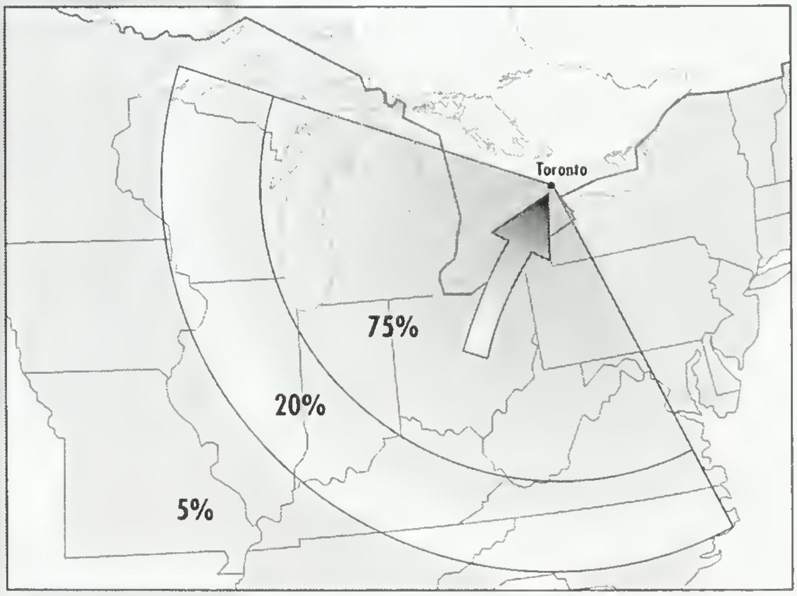


Figure 2.1
U.S. Source Regions of Trans-boundary Ozone

Significant amounts of ozone and ozone-forming compounds are carried into Ontario from the U.S. During periods of widespread elevated ozone, it is estimated that more than 50 per cent of Ontario's ground-level ozone can be attributed to trans-boundary pollution. Figure 2.1 shows the areas from which southern Ontario air arrives during days of widespread elevated ozone levels. Whenever high ozone was recorded, the air mass had resided over the high emission areas of the midwest U.S. and moved into Ontario.

Monitoring results for 1998

Ground-level ozone was monitored at 38 locations during 1998. The lowest annual mean (17.8 parts per billion) was measured at the Toronto Downtown location while the highest mean (32.9 ppb) was measured at Long Point, a rural site on the northern shore of Lake Erie. Generally, ozone is lower in urban areas because it is removed by reaction with nitric oxides emitted locally by vehicles.

Among urban sites, York recorded the highest one-hour concentration (140 ppb), London recorded the greatest number of instances (123) of ozone above the one-hour AAQC of 80 ppb, and Sudbury in Northern Ontario recorded the highest annual urban mean (29.1 ppb).

At rural sites, Grand Bend on the eastern shore on Lake Huron recorded the highest one-hour concentration (138 ppb) and Long Point on the northern shore of Lake Erie recorded the greatest number of instances of elevated ozone (226).

Ground-level ozone is the pollutant that exceeds its provincial ambient air quality criterion (AAQC) most often. In 1998, Ontario's one-hour ozone criterion (80 ppb) was exceeded at 36 of 38 monitoring stations on at least one occasion. All ozone monitoring sites in southern Ontario recorded at least one hour of elevated ozone (above 80 ppb) in 1998. At these levels, people with heart and lung problems are at higher risk. Sensitive people may have trouble breathing and their health may be affected if they engage in vigorous exercise.

Figure 2.2 shows the geographical distribution of the number of hours of elevated ozone concentrations across Ontario. The higher numbers are found at

Ground-level ozone is the pollutant that exceeds its provincial AAQC most often

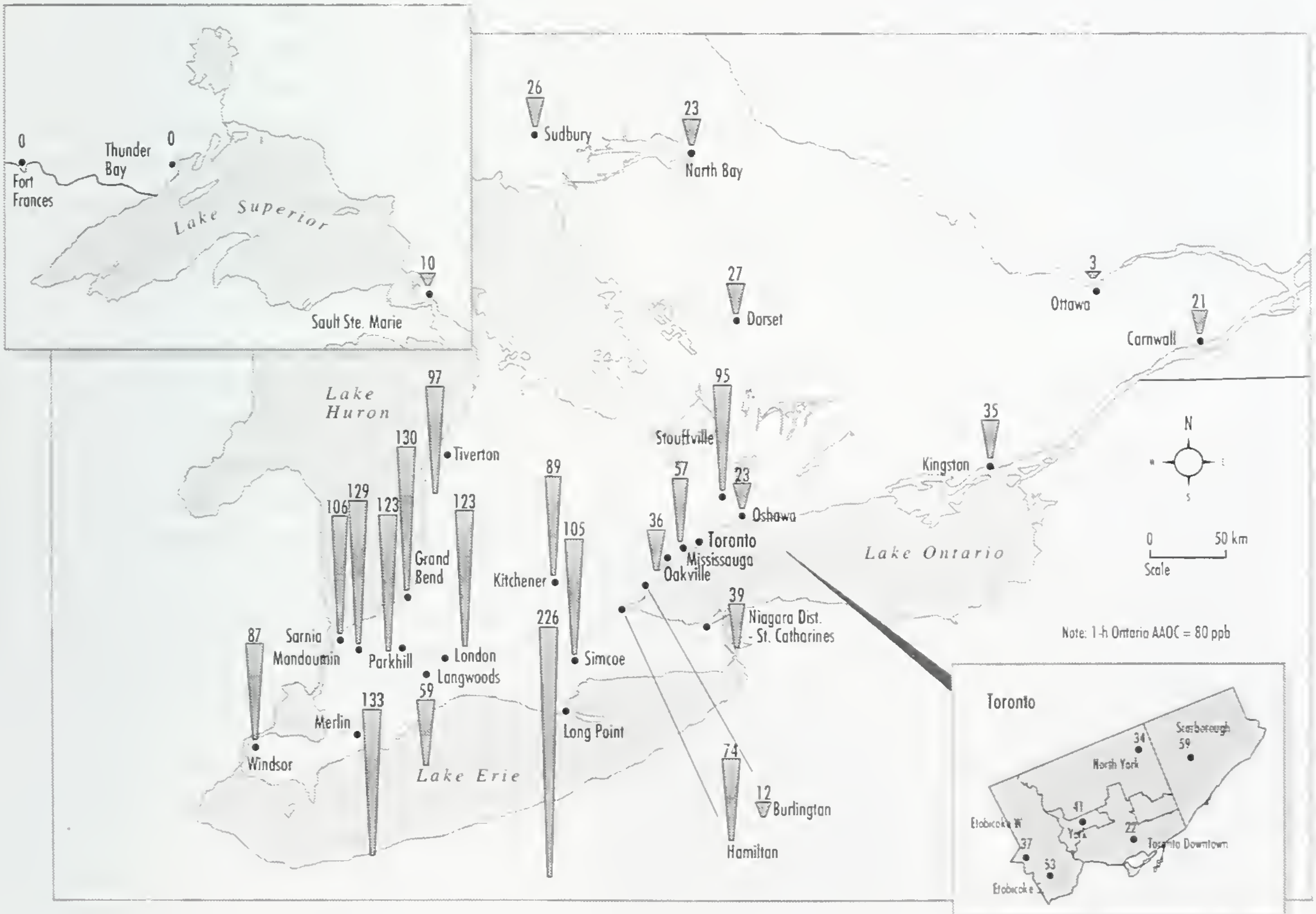
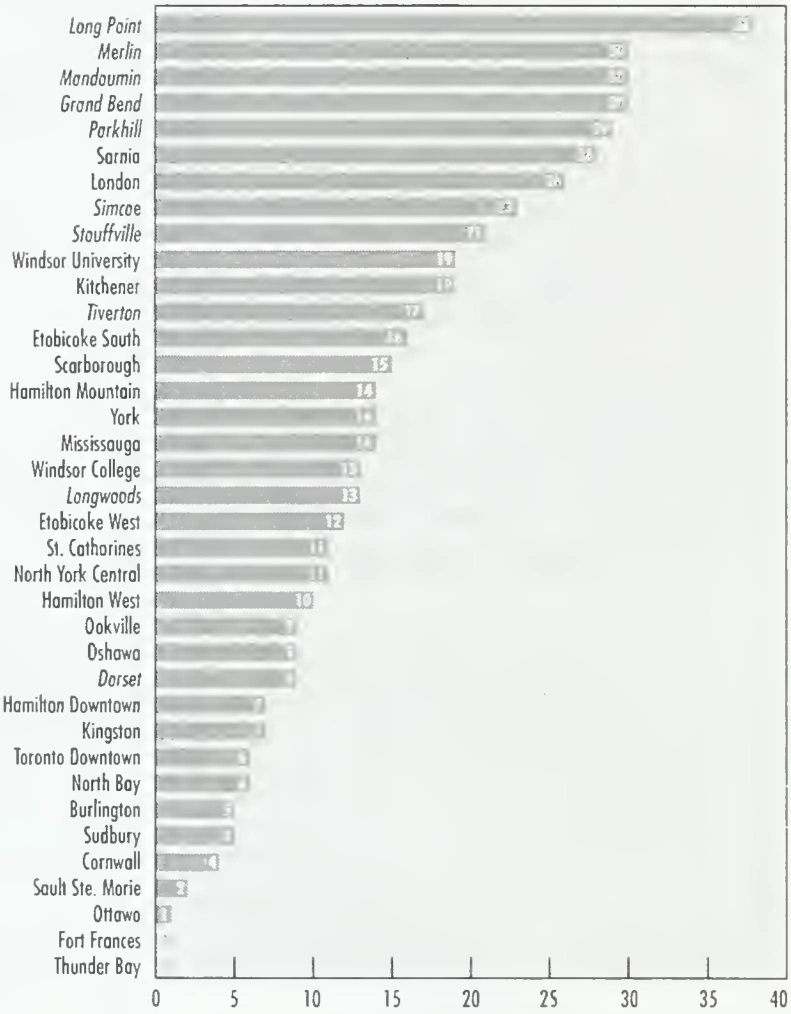


Figure 2.2

Geographical Distribution of 1-hour Ozone Exceedances Across Ontario (1998)

Figure 2.3

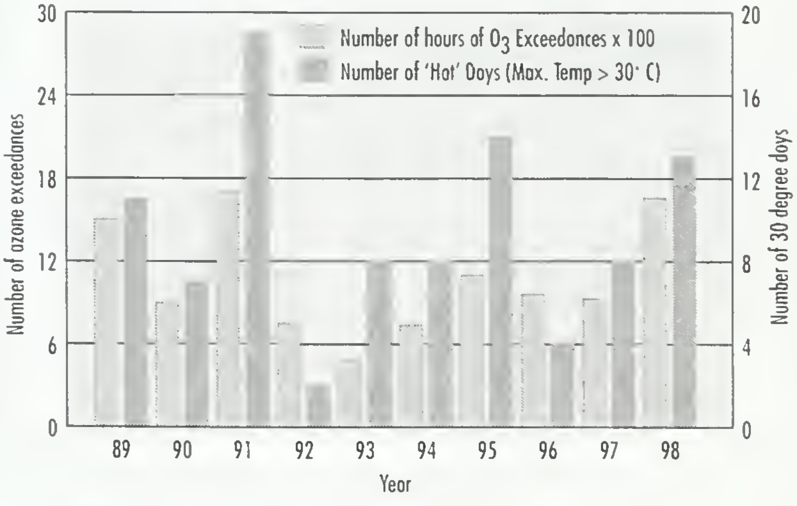
Number of Ozone Exceedance Days at Sites Across Ontario (1998)



Note: Rural sites are italicized; an ozone exceedance day has at least 1 hour > 80 ppb

Figure 2.4

10-Year Trend for Ozone Exceedances and 'Hot' Days (1989-1998)



Note: For 22 ozone sites operated over 10 years

rural sites in the southwestern part of the province, along both the eastern shore of Lake Huron and the northern shore of Lake Erie. The seriousness of transboundary flow is reflected in the relatively higher levels measured there.

Figure 2.3 shows the number of ozone exceedance days (a day with at least one hour above the 80 ppb AAQC) at sites across Ontario. The seven ozone sites recording the highest number of ozone exceedance days in 1998 are located in southwestern Ontario and the top five sites are found in rural areas. Long Point, a rural site on the north shore of Lake Erie, recorded the most exceedance days (38) or about 10 per cent of the days in 1998.

It should be noted that, in general, ozone levels in Ontario decrease from west to east and south to north. As mentioned earlier, more than 50 per cent of provincial ozone levels during widespread ozone episodes are due to long-range transport of ozone and its precursors from neighbouring U.S. states.

Trends

Interpretation of the 10-year ambient ozone trends is complicated by meteorology and emission changes from day to day. Year to year, ozone levels are strongly influenced by weather. Figure 2.4 shows the distribution of province-wide instances of elevated ozone and the number of "hot" days (those with maximum air temperatures greater than 30 degrees C) for 1989 to 1998. Just as the highest number of one-hour elevated levels in 1991 is likely attributable in part to the weather (highest number of "hot" days), so probably the low numbers in 1992 reflect conditions less conducive to production of ground-level ozone. The 1998 ozone season recorded the second highest number of one-hour elevated levels and the third

Emissions of VOCs show a decreasing trend for the period 1989 to 1995.

highest number of "hot" days during the 10-year period.

Emissions of VOCs show a decreasing trend for the period 1989 to 1995, after which they have remained fairly constant (Figure 2.5). New vehicle emission standards in the early 1990s and the shift in the consumption of residential fuels from oil and wood to natural gas probably contributed to this decreasing trend. Emissions from forest fires and natural sources are not included in this trend.

The introduction of lower gasoline volatility (from 82.8 kPa to 72.0 kPa), beginning in 1989 for the summer months, has resulted in a 2.2 per cent decrease in provincial VOC emissions in 1998 and an overall 10.0 per cent reduction over the ten-year program period.

The effect of changes in VOC emissions, as a precursor, on ozone production is not obvious from the trend of ozone for 1989 to 1998. However, we must not lose sight of the meteorological variability factor mentioned earlier, which plays a significant role in ozone formation as shown in the unusually hot summer of 1988.

The trend of the ozone seasonal means (summer and winter) for the 18 (12 urban and six rural) long-term ozone sites for the period 1980 to 1998 is shown in Figure 2.6. Over the 18-year period, the seasonal ozone trend shows a 0.5 per cent per year increase during the summer periods and a 0.7 per cent per year increase during the winter periods. For the summer season, 14 of the 18 ozone sites considered showed increases, ranging from 0.4 to 1.9 per cent per year, two sites remained constant and the remaining two sites showed very slight decreases. Over the entire 18-year period, the ozone summer means for the rural and urban sites showed an increase of 0.6 and 0.4 per cent per year, respectively. A similar analysis of the winter ozone means for the rural and

Figure 2.5

Trend for Ontario VOC Emission Estimates (1989-1998)

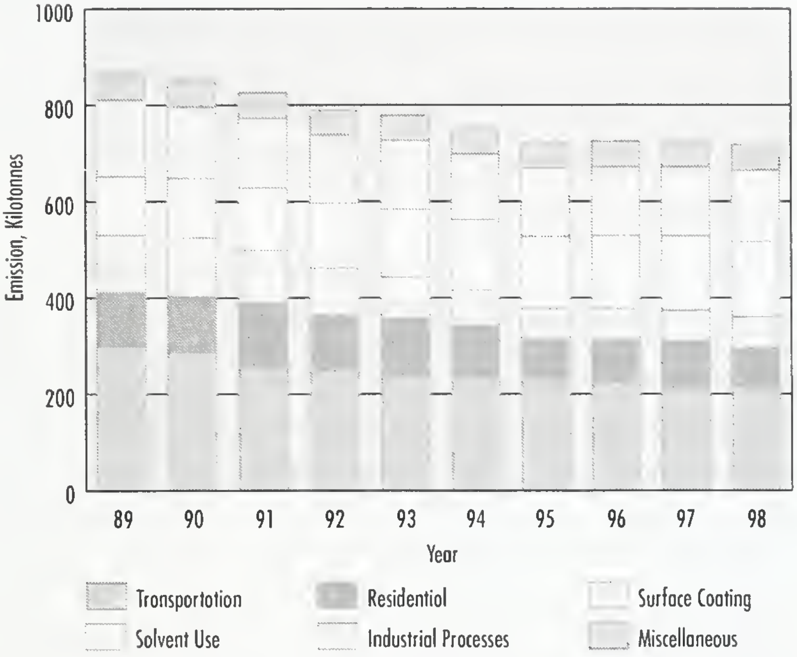
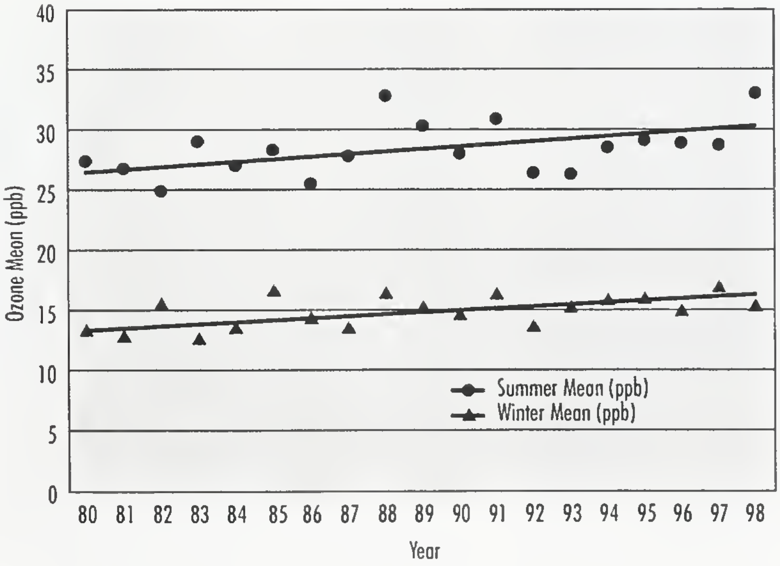


Figure 2.6

Trend of Seasonal Ozone Means at Sites across Ontario (1989-1998)



Note: Data from 18 ozone sites; summer (May to Sept.); winter (Dec. to Feb.)

urban ozone showed an increase of 0.8 and 1.0 per cent per year, respectively, over the 18-year period. It should be noted, however, that there is no significant seasonal ozone trend over the past decade.

Air Quality Advisories are highly dependent on summer weather conditions and generally occur between May and September

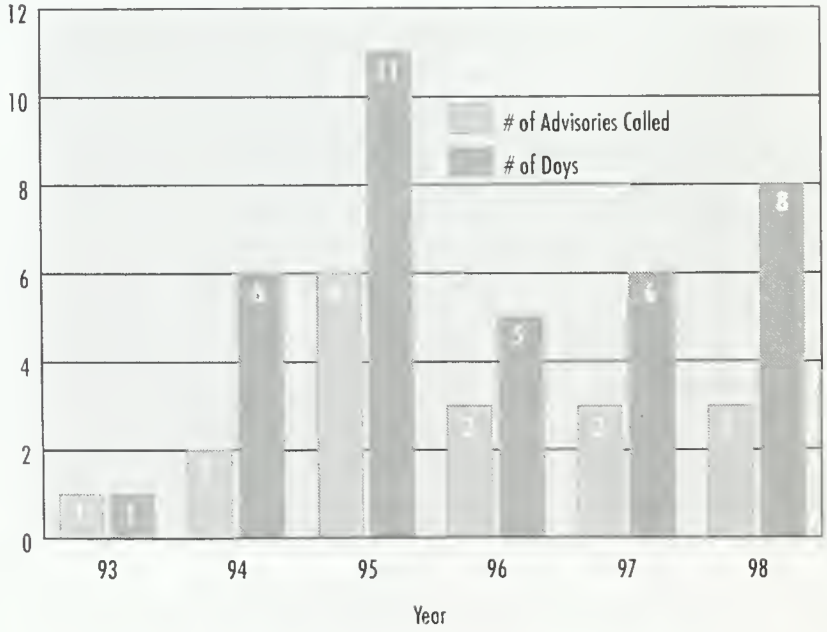
Air quality advisories

Initiated in the spring of 1993 as a joint effort between the Ministry of the Environment and Environment Canada, air quality advisories are issued to the public when elevated pollution levels are forecast due to ground-level ozone. This program builds on Ontario's Air Quality Index (AQI) program, which is discussed in Chapter 5.

Air quality advisories are based on provincial forecasts for ground-level ozone. The advisories are issued regionally by noon the day before expected elevated ozone levels. They encourage people to prevent further deterioration of air quality and outline the effects of air pollution on health and the environment. Air quality advisories are made public via the news media, weather offices and weather radio. They are also available at local ministry offices and through the ministry's Web site: **www.ene.gov.on.ca.**

Figure 2.7

Summary of Air Quality Advisories
(1993-1998)



There are several ways to help reduce ozone (smog) formation. These include limiting driving through car pooling, walking, biking and combining errands; taking public transportation; avoiding excessive idling of vehicles; deferring outdoor chores that use gasoline-powered equipment; postponing the use of oil-based paints and solvents; starting charcoal with an electric starter instead of lighter fluid; and conserving energy use.

Air quality advisories were issued three times in 1998. Two advisories lasted for two-day periods, May 15-16 and June 25-26, and the third advisory lasted for four days, July 13-16. Eighteen advisories have been called over the six years 1993 to 1998 (Figure 2.7). In 1993, there was one advisory lasting one day. This was followed by two advisories in 1994 covering a total of six days, six advisories in 1995 covering 11 days, three advisories in 1996 covering five days, three advisories in 1997 covering six days and three advisories in 1998 covering eight days. The number and duration of air quality advisories are highly dependent on summer weather conditions experienced over southern Ontario between May and September. Regional smog episodes will be discussed in detail in Chapter 6.

CHAPTER 3

Particles in Ontario's Air

Particulate matter (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air

PARTICULATE MATTER (PM) is the general term used for a mixture of solid particles and liquid droplets found in the air. These particles, which come in a wide range of sizes, originate from many different stationary and mobile sources as well as from natural sources. They may be emitted directly from a source or formed in the atmosphere by the transformation of gaseous emissions. Composition varies with place, season and meteorology. This chapter discusses the ambient monitoring results and trends for the 24-hour (sampling every sixth day) inhalable particles (PM_{10}) network, and the real-time continuous inhalable (PM_{10}) and respirable ($PM_{2.5}$) particle network.

Monitoring for 24-hour inhalable particles (PM_{10})

Since 1989 the ministry has increased monitoring for the smaller fraction (less than 10 microns) of the particulate matter because it is more of a health concern, and because it travels long distances and is linked to trans-boundary pollution. As a result of this growing concern, and as a first step, Ontario introduced an interim inhalable particulate criterion of 50 μg/m^3 on a 24-hour basis in November 1997. This level will be used as a yardstick for assessing the data analyzed in the following discussion.

Twenty-four hour inhalable particles (six-day sampling cycle) are measured by a modified hi-volume (hi-vol) sampler outfitted with a size selective inlet to restrict particle size to less than 10 microns. This is the size range of the particle most likely to be inhaled and deposited into the deepest part of the lung (thoracic region). The daily mass of the inhalable particle is computed from the mass of the collected particles and the volume of air sampled. Quartz fibre filters are used as the filter medium for collection.

In 1998, 24-hour PM_{10} levels were measured at 26 urban locations. Thirteen of the 26 sites monitored for ambient levels and will be included in the discussion here. Annual statistics for the remaining 13 sites, which monitored in the vicinity of specific sources, can be found in the separate appendix document.

CLEAN AIR TIP

Drive Clean by avoiding excessive idling of vehicles, keeping your car well tuned, driving at moderate speeds and refuel your car after sundown.

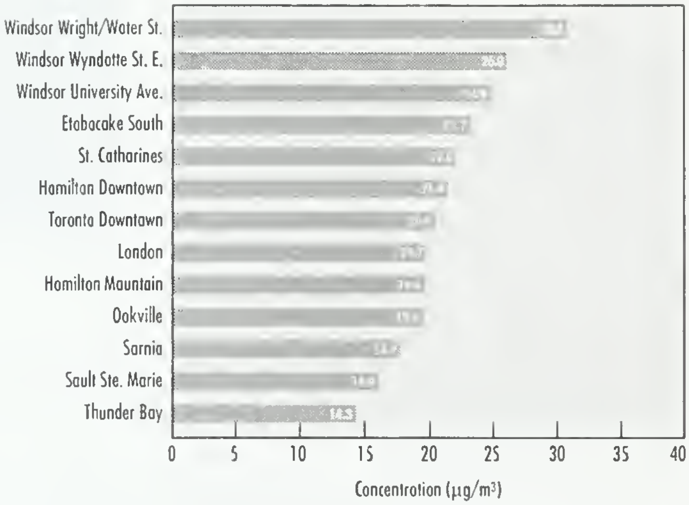


Figure 3.1

24-hour PM_{10} Annual Geometric Means at Ambient Sites Across Ontario

(1998)

Table 3.1

Percentage of 24-Hour PM10 Exceedance Days at Ambient Sites

(1998)

Station Number	Station Location	% of Days > 50 µg/m³
12513	Windsor Wyndotte St. East	17.0
12507	Windsor Wright/Water St	14.3
12508	Windsor University Ave	8.7
31127	Toronto Downtown	5.0
44127	Oakville	3.6
29300	Hamilton Downtown	3.4
71368	Sault Ste Marie	3.4
14550	Sarnia	1.8
29324	Hamilton Mountain	1.8
15525	London	1.7
27308	St Catharines	1.7
35127	Etobicoke South	1.7
63201	Thunder Bay	0.0

Note: Ontario 24-hour interim criteria for PM_{10}

Figure 3.1 shows the distribution of mean annual PM_{10} levels at ambient sites across Ontario. The highest annual geometric mean (30.8 µg/m³) and the maximum 24-hour concentration (133.0 µg/m³) of PM_{10} were measured in Windsor. In fact, the three monitoring locations in Windsor recorded the highest annual geometric means, indicating trans-boundary impact.

Twelve of the 13 ambient PM_{10} sites recorded exceedances of the 24-hour interim criterion (50 µg/m³) during 1998, as shown in Table 3.1. The highest percentages were recorded at the three sites in Windsor and ranged from 8.7 per cent at Windsor University to 17.0 per cent at the Windsor Wyndotte Street East site, once again indicating trans-boundary impact.

Trends in 24-hour PM_{10}

The provincial trend in 24-hour PM_{10} levels for six ambient urban locations over the past eight years is shown in Figure 3.2. No trend is apparent. However, the highest composite geometric mean (22.1 µg/m³) was measured in 1994 and the lowest mean (18.4 µg/m³) in 1995 and 1997. The 1998 composite mean was 19.4 µg/m³.

Monitoring results for selected trace metals and sulphate in PM_{10}

Selected trace metals and sulphate in PM_{10} concentrations were measured at 13 ambient urban locations during 1998. The selected trace metals include iron, copper and manganese. For iron in PM_{10}, the highest mean (0.70 µg/m³) and the maximum 24-hour concentration (12.0 µg/m³) were measured in Windsor. For manganese in PM_{10} the highest mean (0.038 µg/m³) was measured in downtown Hamilton and the maximum 24-hour value (0.640 µg/m³) in Windsor. The highest measured copper annual mean (0.025 µg/m³) and the maximum 24-hour value (0.08 µg/m³)

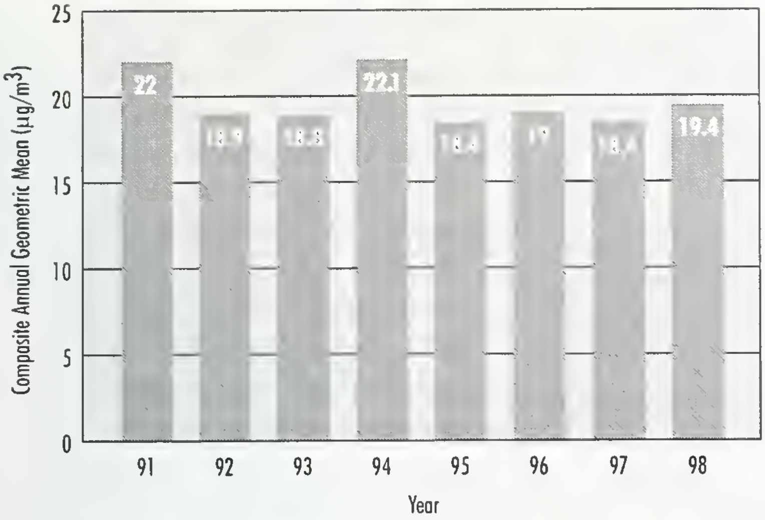


Figure 3.2
Trend for 24-hour PM_{10}
(1991-1998)

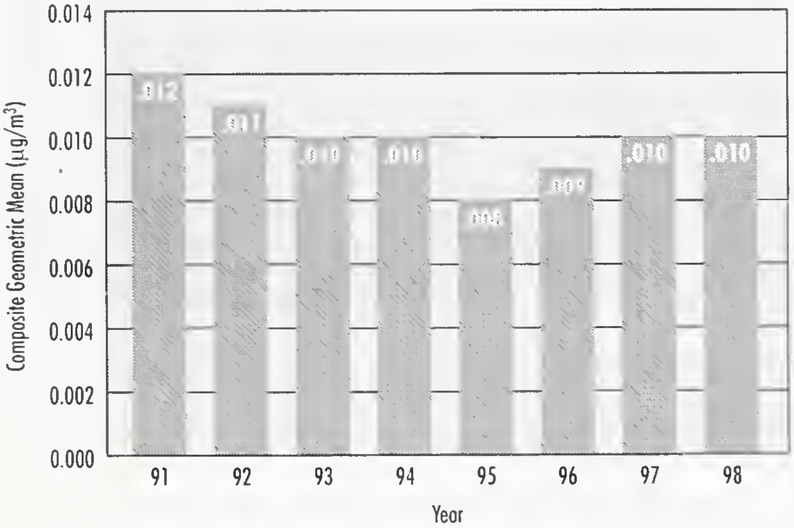
Note: Data for six ambient urban sites

were measured in Hamilton during 1998. For sulphate in PM_{10} the highest mean (4.4 µg/m³) was measured in Windsor and the maximum 24-hour concentration (24.2 µg/m³) in Sarnia.

Trends for selected metals and sulphate in PM_{10}

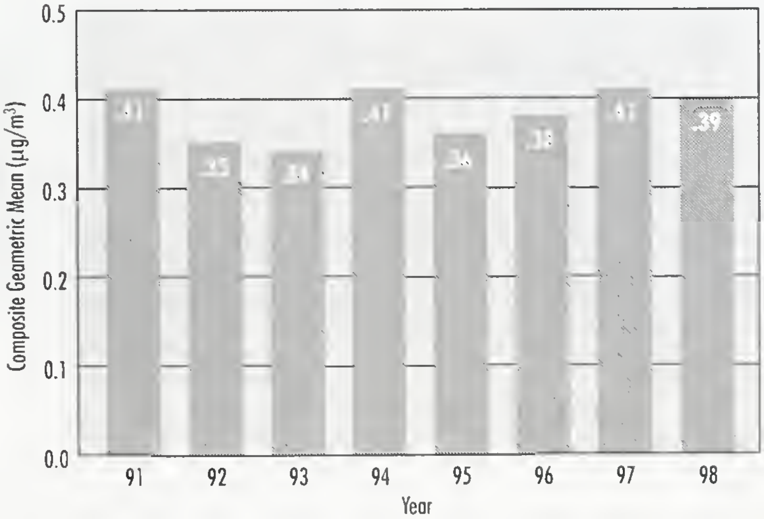
The provincial composite trends in copper, iron, manganese and sulphate in 24-hour PM_{10} for six urban locations from 1991 to 1998 are shown in Figures 3.3 to 3.6, respectively. Sulphate in PM_{10} shows a slight decreasing trend over the eight-year period while iron and manganese are fairly constant over the same period. Copper in PM_{10} shows a decrease for the first four years and a slight increase during the last four years (1995 to 1998).

Figure 3.3
Trend for Copper in PM_{10}
(1991-1998)



Note: Data for six ambient urban sites

Figure 3.4
Trend for Iron in PM_{10}
(1991-1998)



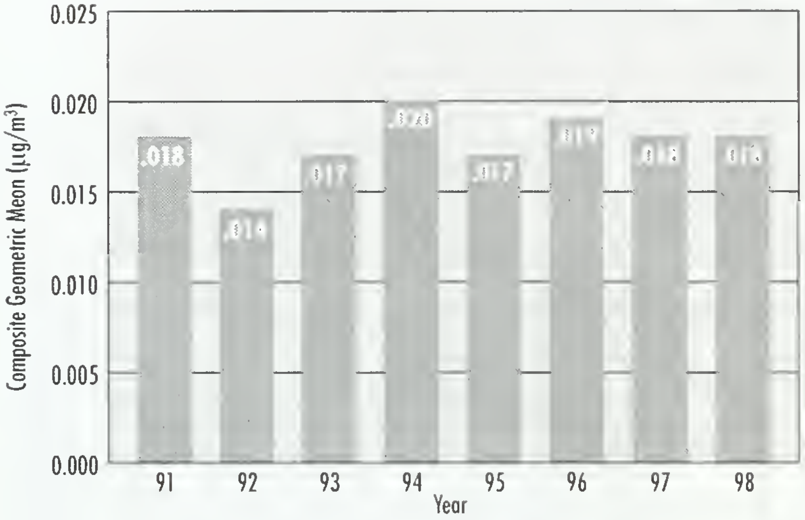
Note: Data for six ambient urban sites

Plans are underway to incorporate fine particles into Ontario's Air Quality Index system

Figure 3.5

Trend for Manganese in PM_{10}

(1991-1998)

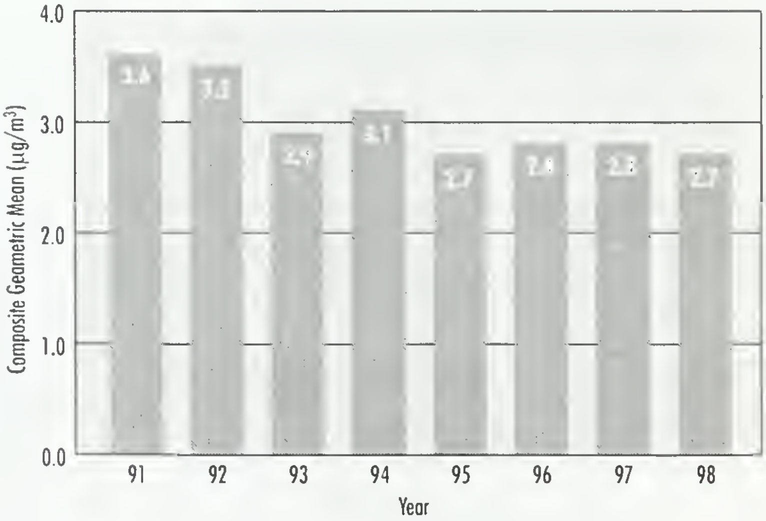


Note: Data for six ambient urban sites

Figure 3.6

Trend for Sulphate in PM_{10}

(1991-1998)



Note: Data for six ambient urban sites

Real-time $PM_{10}/PM_{2.5}$ monitoring

In June of 1995, the ministry installed a state-of-the-art continuous (inhalable and respirable) monitoring network of five sites across the province. By 1998 this network has increased in size to a total of 21 sites, nine PM_{10} and 12 $PM_{2.5}$. Continuous hourly measurements of inhalable and respirable particles are obtained by the Tapered Element Oscillating Microbalance (TEOM) method. The TEOM measures the accumulation of mass on a heated filter attached to the tip of a hollow, tapered, oscillating glass rod. From change in oscillating frequency, direct measurement of mass accumulation on the filter over time is obtained. The $PM_{10}/PM_{2.5}$ monitoring is intended to allow capture of immediate changes in fine particle levels in urban communities, near local industries and in areas affected by trans-boundary sources. Plans are under way to eventually incorporate real-time PM into Ontario's Air Quality Index system.

Monitoring results for real-time PM_{10}/$PM_{2.5}$

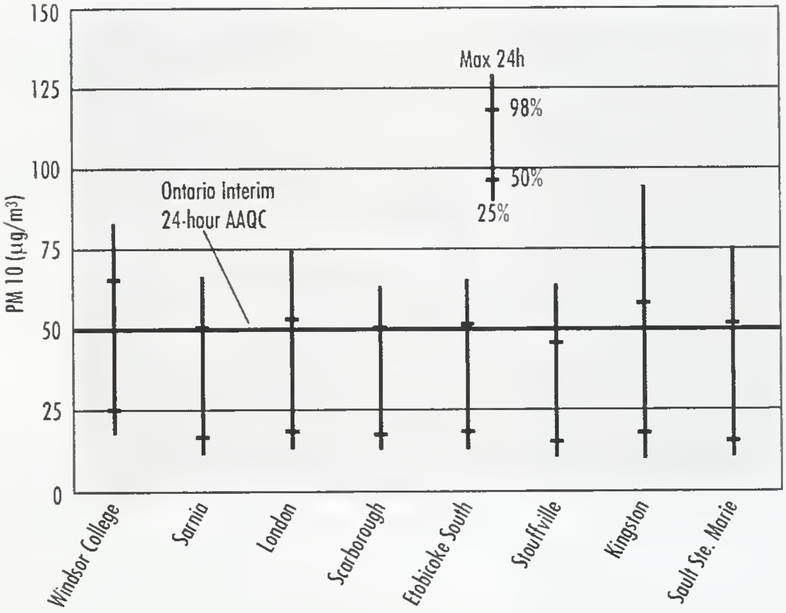
In 1998, monitoring for real-time PM_{10} was conducted at a total of nine ambient monitoring locations. Eight of the nine sites recorded sufficient data to be used in this discussion, and their 24-hour statistics for 1998 are shown in Figure 3.7. The annual mean levels for PM_{10} at the eight ambient sites ranged from a low of 17.6 µg/m^3 in Stouffville to a maximum of 28.6 µg/m^3 in Windsor. The highest 24-hour average (94.1 µg/m^3) was recorded in Kingston. The 24-hour interim PM_{10} criterion of 50 µg/m^3 was exceeded on 36 days (10 per cent of the year) in Windsor and on 19 days (5 per cent of the year) in Kingston. However, note that the Kingston site is adjacent to a truck depot and may not be representative of the greater Kingston area. Ninety per cent of all measured 24-hour averaged concentrations at the ten ambient sites were below 50 µg/m^3.

In 1998, continuous monitoring for $PM_{2.5}$ was conducted at a total of 12 ambient monitoring locations. Ten of the 12 sites recorded sufficient data to be discussed here and their 24-hour statistics are shown in Figure 3.8. The maximum annual mean 16.3 µg/m^3 and the maximum 24-hour average 67.3 µg/m^3 were recorded at the Hamilton Mountain and downtown Hamilton sites, respectively. The provincial average for $PM_{2.5}$ during 1998 was 13.2 µg/m^3.

In 1998, monitoring for real-time fine particles was conducted at a total of 21 ambient monitoring locations.

Figure 3.7

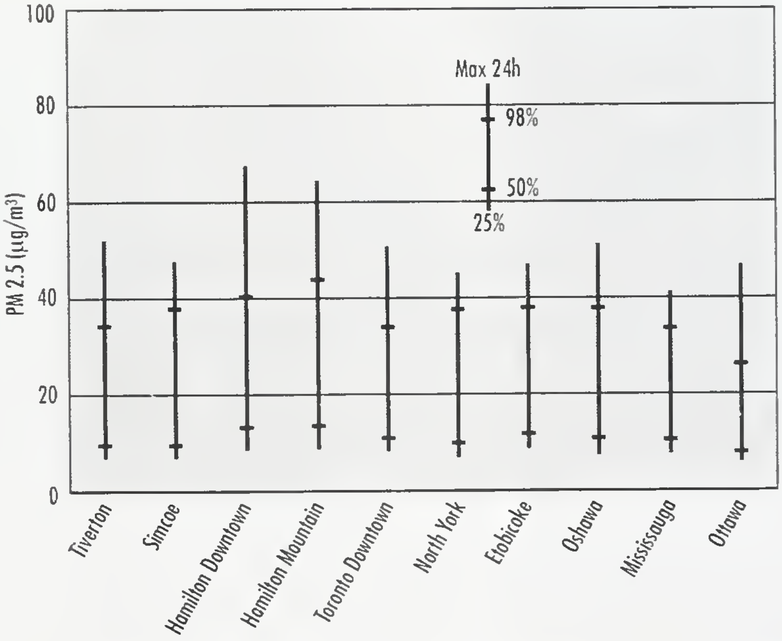
Summary Statistics for 24-Hour PM_{10} as Measured by TEOM (1998)



Note: Data from ambient sites.

Figure 3.8

Summary Statistics for 24-Hour $PM_{2.5}$ as Measured by TEOM (1998)



Note: Data from ambient sites

Other Principal Contaminants

Monitoring for SO_2 was performed at 29 ambient locations during 1998.

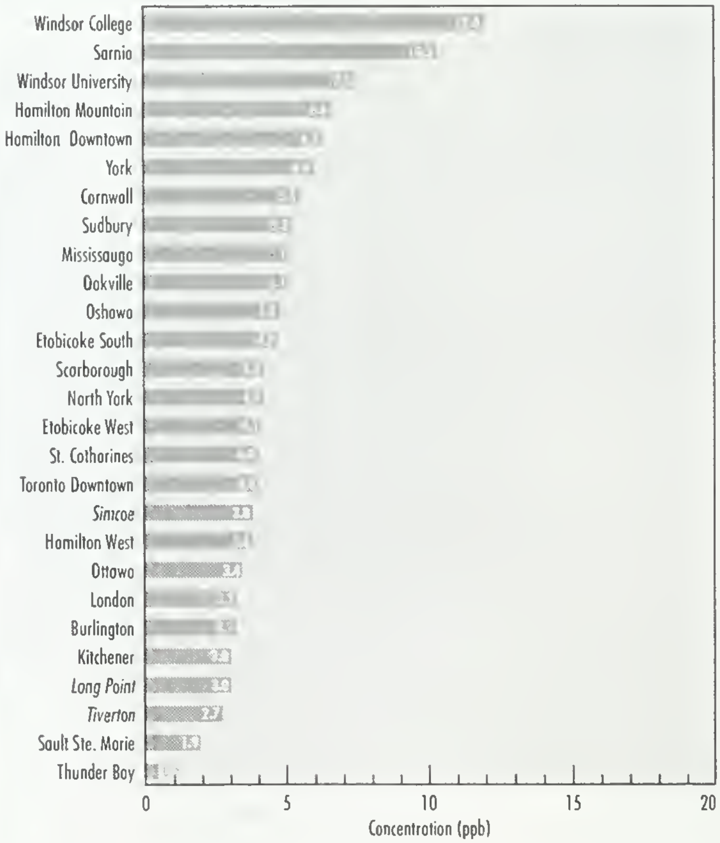
POLLUTANTS SO_2, NO_2, CO AND TRS COMPOUNDS are discussed in this chapter, as well as their ambient concentrations for 1998 and trends over time. Corresponding annual emission estimate trends are also discussed.

SULPHUR DIOXIDE (SO_2)

Monitoring results for 1998

Monitoring for SO_2 was performed at 27 ambient locations during 1998. Windsor College recorded the highest annual mean (12.0 ppb), Science North in Sudbury recorded the highest one-hour concentration (414.0 ppb) and Sarnia recorded the maximum 24-hour value (110.2 ppb). Two ambient stations, one in Sudbury and the other in Sarnia, recorded instances above the SO_2 one-hour criterion of 250 ppb. Sudbury had six such hours and Sarnia one. There was one instance of exceeding the 24-hour AAQC of 100 ppb during 1998. This was recorded at the Sarnia Centennial Park monitor.

Figure 4.1 shows the annual mean SO_2 concentrations at ambient sites across Ontario. Windsor, Sarnia and Hamilton recorded the highest annual levels in 1998. The annual criterion for SO_2 was not exceeded during 1998.



Note: Ontario annual AAQC is 20 ppb; rural sites are italicized.

Figure 4.1
SO_2 Annual Mean Concentrations at Ambient Sites Across Ontario (1998)

CLEAN AIR TIP

During a Smog Alert, put off doing outdoor chores that use gasoline-powered equipment until the air is clear.

Trends

Over the long term, 1971 to 1998, Ontario's SO_2 emissions decreased 79 per cent, while average SO_2 levels in the province improved by 82 per cent during the same period (Figure 4.2).

Regulations 346 and 350, control orders on smelting operations and the Countdown Acid Rain program have resulted in these significant decreases over the long term. Over the short term, however, SO_2 emissions have shown a slight increasing trend since 1994. This has resulted from a strong economic growth in Ontario over the same period. SO_2 emissions from Ontario Hydro's thermal power plants across the province have increased by about 15 to 20 per cent since 1997. This is likely due to the shutdown of seven nuclear reactors at the Pickering and Bruce power plants. However, overall SO_2 emissions in 1998 are down slightly from 1997 because of reductions in the smelters and other industrial sectors. The total Ontario SO_2 emissions in 1998 were 706 kilotonnes, up from the 1996 total of 676 kilotonnes, but well below the 1994 countdown limit of 885 kilotonnes.

Lambton industry meteorological alert (LIMA)

The Lambton industry meteorological alert is covered by the *Environmental Protection Act*, Regulation 350. Application is limited to that part of the County of Lambton bounded by Lake Huron, the St. Clair River, Highway 80, Moore Township and its continuation through that part of Highway 40, and Lambton County Road 27, which includes Sarnia.

The Minister may declare an alert when the 24-hour running average SO_2 concentration at any station in the LIMA system reaches 70 ppb and meteorological forecasts indicate six hours or more of conditions conducive to elevated SO_2 concentrations. The alert is issued at 70 ppb to prevent levels reaching the Ontario 24-hour AAQC for SO_2 (100 ppb).

Two monitoring sites are located in Sarnia (Front Street and Centennial Park) and one in Corunna (River Bend).

Six alerts were issued during 1998. Five of these were based on measurements from the Front Street monitor and one alert was based on measurements from Centennial Park The highest 24-hour SO_2 running average (137.0 ppb) was recorded at Front Street during the LIMA of Nov. 30. LIMA alerts called during the past 18 years are shown in Figure 4.3. On average, there have been six alerts called per year since the inception of the program in 1981.

Over the long term, 1971 to 1998, Ontario's SO2 emissions decreased 79 per cent.

Figure 4.2
Long-Term Trend for Sulphur Dioxide
(1971-1998)

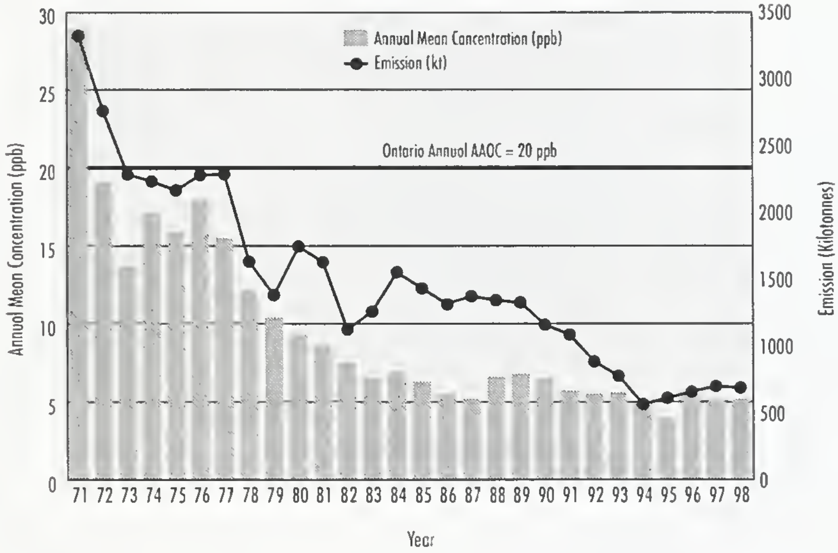


Figure 4.3
Lambton Industry Meteorological Alert (LIMA) Summary
(1998)

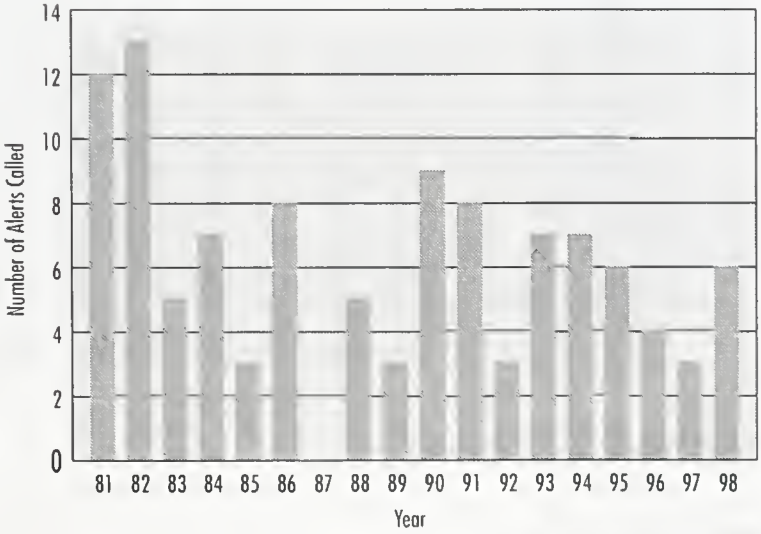
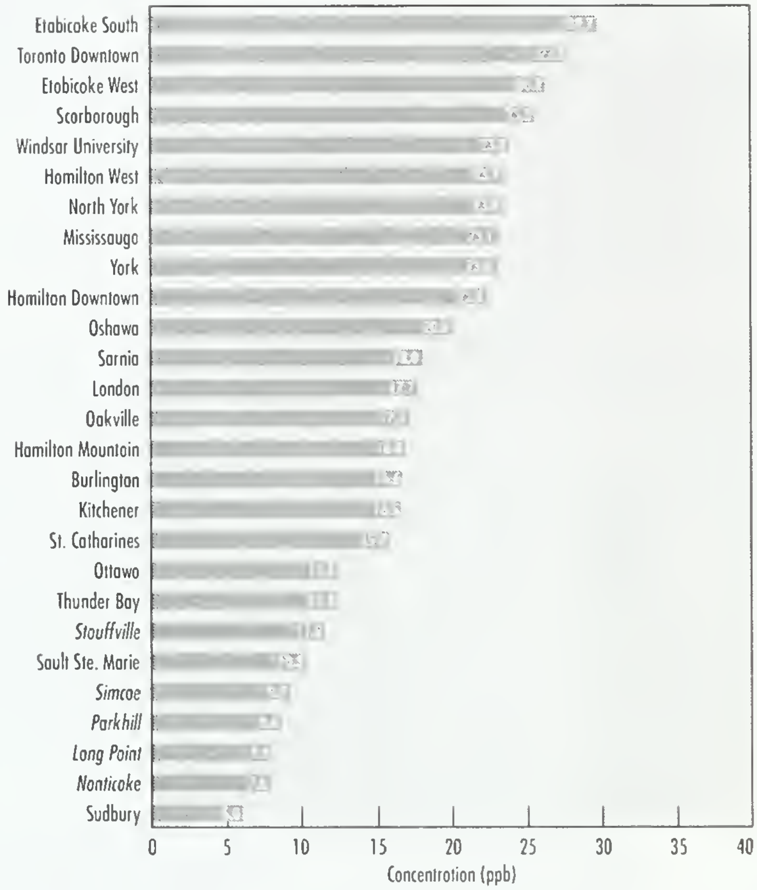


Figure 4.4

NO_2 Annual Mean Concentrations at Ambient Sites Across Ontario

(1998)

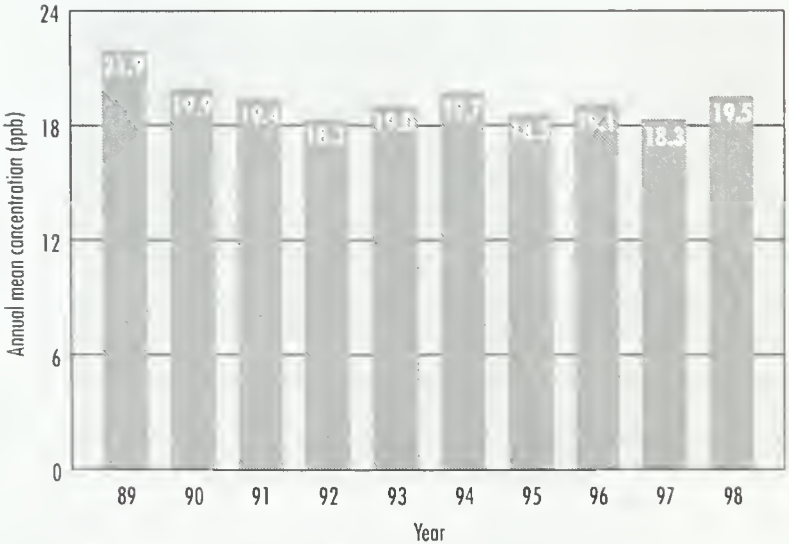


Note: Rural sites are italicized.

Figure 4.5

10-Year Trend for NO_2 Levels

(1989-1998)



Note: 17 Sites operated over 10 years

NITROGEN DIOXIDE (NO_2)

Monitoring results for 1998

Nitrogen dioxide was monitored at 27 ambient locations in 1998. Etobicoke South recorded the highest annual mean concentration (29.7 ppb), Windsor the maximum one-hour concentration (117.0 ppb) and Hamilton Mountain the maximum 24-hour concentration (68.4 ppb) during 1998. Typically, highest NO_2 annual mean concentrations are recorded in larger urban centres such as Toronto, Windsor and Hamilton due to their large vehicle fleets (Figure 4.4). The one-hour criterion of 200 ppb for NO_2 and the 24-hour limit of 100 ppb were not exceeded during 1998.

Trends

Provincial average ambient NO_2 levels have remained relatively constant throughout the 1990s. Average concentrations in 1998 were about 11 per cent lower than the levels recorded in 1989 (Figure 4.5). Provincial NO_x emissions decreased 25 per cent during the period 1989 to 1994. This decrease is attributed to reductions in emissions from the industrial and transportation sectors. Since 1995 there has been little change in estimated emissions of NO_x (Figure 4.6).

CARBON MONOXIDE (CO)

Monitoring results for 1998

Carbon monoxide was monitored at 21 ambient locations in 1998. The highest annual mean (1.1 parts per million) was recorded in several urban locations, including downtown Toronto, Hamilton, Mississauga and Ottawa. The highest eight-hour measured value (4.6 ppm) was recorded at Burlington while the highest one-hour concentration (8.0 ppm) was measured in Oshawa and at the York monitor in Toronto. Highest CO levels are recorded typically in larger urban centres as a result of vehicle emissions (Figure 4.7). There were no instances of exceeding the one-hour or eight-hour AAQC in 1998. The CO one-hour (30 ppm) and eight-hour (13 ppm) ambient air quality criteria (AAQC) have not been exceeded since 1991.

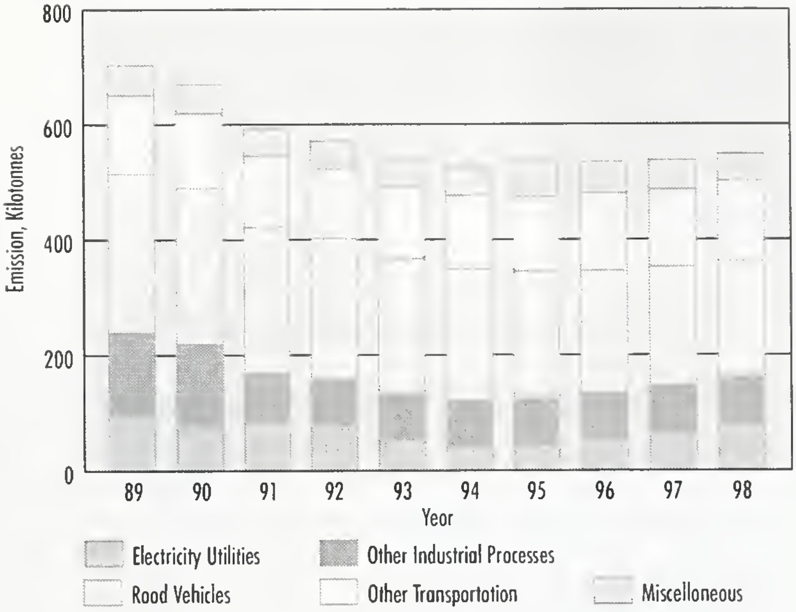


Figure 4.6

Trend for Ontario NO_x Emissions Estimates

(1989-1998)

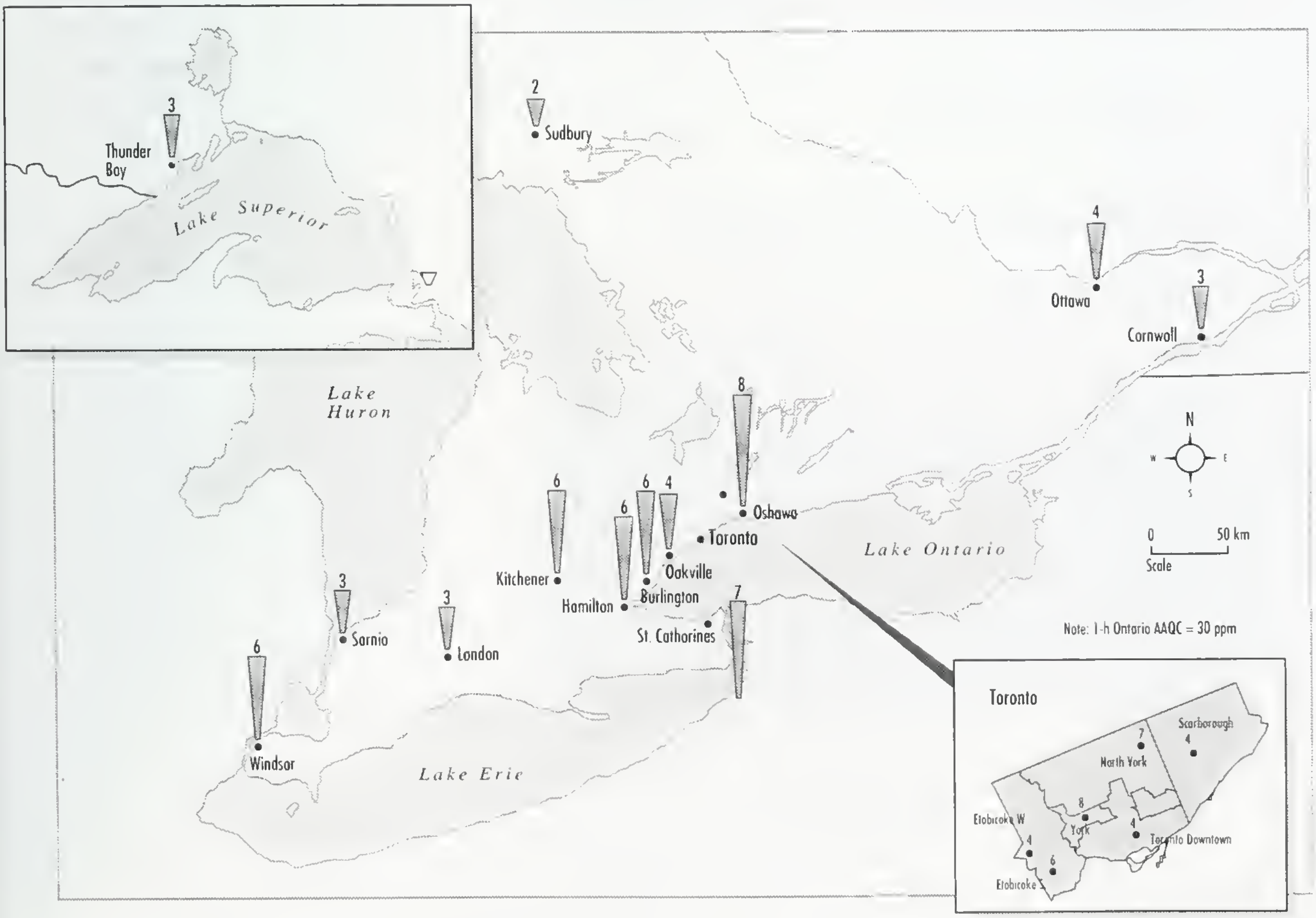


Figure 4.7

Geographical Distribution of 1-Hour Maximum CO Concentrations (ppm) Across Ontario

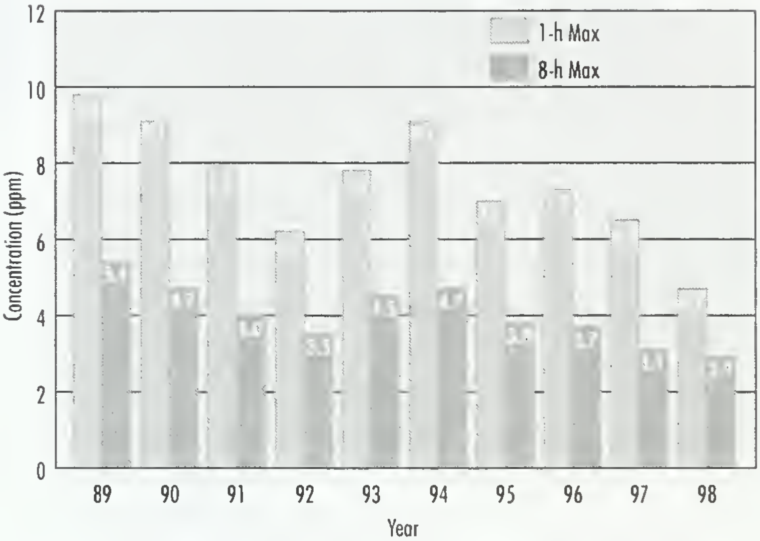
(1998)

Provincial CO emissions show a decline since 1989

Figure 4.8

10-Year Trend for CO 1-Hour and 8-Hour Maxima

(1989-1998)

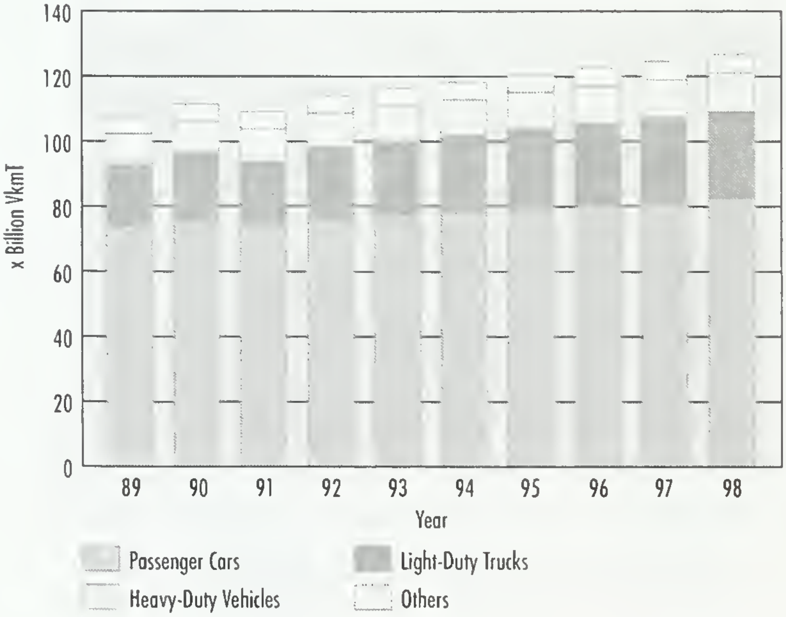


Note: 1-h AAQC = 30ppm; 8-h AAQC = 13ppm

Figure 4.9

Trend for Ontario Vehicle-Kilometres Travelled (VkmT)

(1989-1998)



Trends

The trends in provincial averaged one-hour and eight-hour maximum CO concentrations are shown in Figure 4.8 for the period 1989 to 1998. Over this 10-year period, ambient CO concentrations as measured by the composite average of the one- and eight-hour maximums were reduced by 52 and 46 per cent, respectively. Annual mean levels of CO decreased by 25 per cent over that period. These reductions in ambient CO levels occurred despite an 18 per cent increase in vehicle-kilometres travelled over the same 10-year period (Figure 4.9).

Provincial CO emissions show a decline since 1989 due to the fleet change to newer vehicles with more stringent emission standards (Figure 4.10). The transportation sector accounts for 68 per cent of the provincial total CO emissions. Since 1989, emissions from this sector have decreased by about 12 per cent.

TOTAL REDUCED SULPHUR (TRS) COMPOUNDS

Monitoring results for 1998

Monitoring for TRS compounds was carried out at 12 ambient locations in 1998. The highest annual mean concentration (1.3 ppb), the maximum one-hour concentration (132.0 ppb) and the greatest number of hours (28) above the AAQC were all recorded at the Windsor College monitor. Elevated TRS levels in Windsor are mainly attributed to trans-boundary impact from Michigan sources.

Monitoring for TRS compounds was carried out at 12 ambient locations in 1998.

Trends

The 10-year trend in provincial composite averaged TRS levels at ambient monitoring sites is shown in Figure 4.11. A decreasing trend over the 10-year period is evident. Mean averaged ambient TRS levels in 1998 are 30 per cent lower than they were in 1989. This decrease is mainly attributed to abatement and regulatory action taken by the ministry over the years.

Figure 4.10

Trend for Ontario Carbon Monoxide Emission Estimates

(1989-1998)

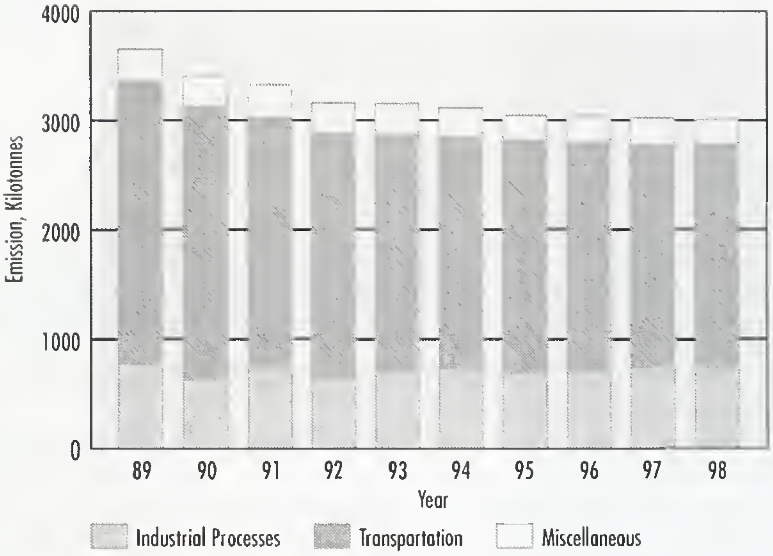
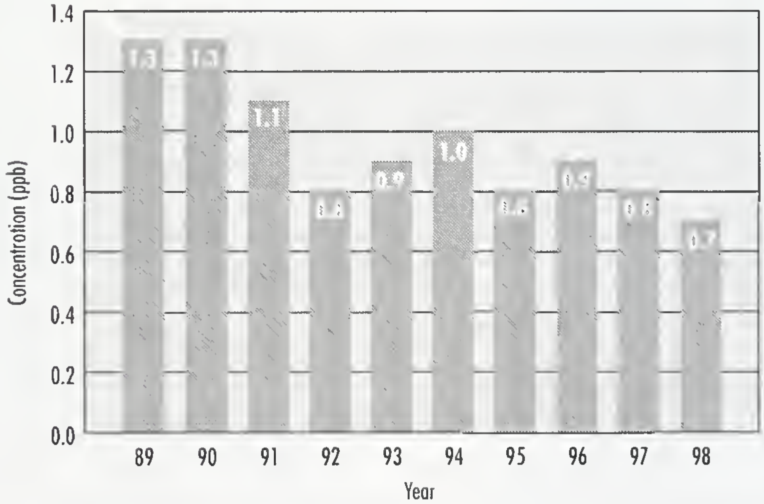


Figure 4.11

10-Year Trend for Annual Mean TRS Levels (ppb) at Ambient Sites

(1989-1998)



Note: 12 Sites operated over 10 years

In 1998, the Air Quality Index was reported for 27 sites in 24 urban centres across the province.

Air Quality Indices

CHAPTER 5

Air Quality Index (AQI)

THE MINISTRY OF THE ENVIRONMENT operates an extensive network of air quality monitoring sites across the province. Twenty-seven of these sites in 24 urban centres form the basis of the AQI network. The Air Quality Office at the Environmental Monitoring and Reporting Branch continually obtains data from the 27 AQI sites.

This network, in place since the summer of 1988, provides the public with real-time air quality information across the province. The AQI is based on pollutants that have adverse effects on human health and the environment. The pollutants are sulphur dioxide (SO_2), ozone (O_3), nitrogen dioxide (NO_2), total reduced sulphur (TRS) compounds, carbon monoxide (CO) and suspended particles (SP). At the end of each hour, the concentration of each pollutant measured at a particular site is converted into a number that ranges from zero upwards using a common scale or index. The calculated number for each pollutant is called a sub-index.

The highest sub-index for any given hour becomes the AQI for a particular site. The lower the index, the better the air quality. The index values, corresponding categories and potential health and environmental effects are shown in Table 5.1.

If the AQI value is below 32, the air quality is considered good since there are no known health effects. For AQI values in the 32-49 range there may be some adverse health effects on very sensitive people. An index value in the 50-99 range may have adverse effects on the most sensitive of the human or animal populations, or may cause significant damage to vegetation and property. An AQI value of 100 or more may cause adverse effects to the health of a large proportion of those exposed.

The Air Pollution Index (API) is also a sub-index of the AQI. The basis of an alert and control system to warn of deteriorating air quality, the API is derived from 24-hour running averages of SO_2 and SP.

CLEAN AIR TIP

Use air-friendly products, and avoid using aerosol sprays and cleaners, oil-based paints and other chemical products that contribute to poor air quality.

Computed air quality indices and air quality forecasts are released to the public and news media at set intervals each day.

Computed air quality indices and air quality forecasts are released to the public and news media at set intervals each day. The public can access the index values by calling the ministry's automatic telephone answering device (English recording: 1-800-387-7768 or in Toronto 416- 246-0411. French recording: 1-800-221-8852). The AQI can also be obtained from the ministry's Web site: **www.ene.gov.on.ca**.

Air quality forecasts are provided daily based on meteorological conditions and short term pollutant trends in Ontario and bordering U.S. states.

Table 5.1

Air Quality Index Pollutants and Their Impact

Index	Category	Carbon Monoxide (CO)	Nitrogen Dioxide (NO2)	Ozone (O3)	Sulphur Dioxide (SO2)	Suspended Particles (SP)	SO2 + SP (As measured by the API)	Total Reduced Sulphur (TRS)
0-15	Very good	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects
16-31	Good	No known harmful effects	Slight odour	No known harmful effects	Damages some vegetation in combination with ozone	No known harmful effects	No known harmful effects	Slight odour
32-49	Moderate	Blood chemistry changes , but no noticeable impairment	Odour	Respiratory irritation in sensitive people during vigorous exercise; people with heart/lung disorders at some risk; damages very sensitive plants	Damages some vegetation	Some decrease in visibility	Damages vegetation (i.e. tomatoes, white beans due to sulphur dioxide)	Odour
50-99	Poor	Increased symptoms in smokers with heart disease	Air smells and looks brown. Some increase in bronchial reactivity in people with asthma	Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart /lung disorders at greater risk; damage to some plants	Odourous; increasing vegetation damage	Decreased visibility; soiling evident	Increased symptoms for people with chronic lung disease	Strong odour
100-over	Very poor	Increasing symptoms in non- smokers heart diseases; with blurred vision; some clumsiness	Increasing sensitivity for people with asthma and bronchitis	Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage	Increasing sensitivity for people with asthma and bronchitis	Increasing sensitivity for people with asthma and bronchitis	Significant effects for people with asthma and bronchitis	Severe odour; some people may experience nausea and headaches

Air quality was most often in the "good to very good" categories at all AQI sites across the province.

Summary Air Quality Index levels (1998)

Table 5.2 shows the frequency distribution of hourly AQI for the 27 AQI monitoring locations, according to descriptive category and pollutant responsible for AQI above 31. Air quality was most often in the "good to very good" categories at all AQI sites across the province. Based on the cumulative total number of monitored hours (230,427) at the 27 sites, on average, good to very good air quality was reported 93.4 per cent of the time. Good to very good air quality readings ranged from 89.5 per cent at London to 98.6 per cent at Thunder Bay. There were 15,289 hours (6.6 per cent of hours monitored) of moderate to poor air quality recorded at the 27 sites in 1998.

Table 5.2

Air Quality Index Summary
(1998)

			Number of Hours AQI in Range					# of hrs Pollutant Responsible for AQI >31							# of days at least 1hr >31	# of days at least 1hr >49
Site ID	City	Valid Hours	V.Good 0-15	Good 16-31	Mod. 32-49	Poor 50-99	V.Poor 100+	[illegible]	O_3	TRS	SO_2	[illegible]	CO	NO_2		
12008	Windsor University	8724	5551	2364	722	87	0	0	809	X	0	0	0	0	116	19
12016	Windsor College	8630	5440	2428	683	79	0	11	575	176	0	0	X	X	145	31
14064	Sarnia	8742	3994	3868	774	106	0	2	865	12	1	0	0	0	119	28
15025	London	8760	4917	2927	793	123	0	0	916	X	0	0	0	0	102	26
Southwest Average		**8714**	**4976**	**2897**	**743**	**99**	**0**	**3**	**791**	**47**	**0**	**0**	**0**	**0**	**121**	**26**
26060	Kitchener	8496	4246	3430	731	89	0	0	820	X	0	0	0	0	109	19
27067	St Catharines	8510	5524	2411	536	39	0	15	560	X	0	0	0	0	82	11
29000	Hamilton Downtown	8656	5188	2919	530	19	0	12	501	36	0	0	0	0	91	7
29114	Hamilton Mountain	8573	4404	3325	770	74	0	15	821	8	0	0	X	0	112	14
29118	Hamilton West	8517	5366	2612	505	34	0	1	531	7	0	0	X	0	83	10
West Central Average		**8550**	**4946**	**2939**	**614**	**51**	**0**	**9**	**647**	**10**	**0**	**0**	**0**	**0**	**95**	**12**
31103	Toronto Downtown	8605	6245	1988	350	22	0	0	372	X	0	0	0	0	71	6
33003	Scarborough	8391	5471	2278	583	59	0	0	642	X	0	0	0	0	93	15
34020	North York	8589	4914	3169	472	34	0	0	506	X	0	0	0	0	86	11
35003	Etobicoke West	7913	4991	2378	507	37	0	1	543	X	0	0	0	0	85	12
35033	Etobicoke South	8580	5791	2234	502	53	0	9	546	X	0	0	0	0	94	16
36030	York	8701	5435	2667	558	41	0	13	586	X	0	0	0	0	107	14
44008	Burlington	8060	4545	3001	502	12	0	2	512	X	0	0	0	0	77	5
44015	Oakville	8731	5015	3033	646	37	0	6	675	2	0	0	0	0	109	10
45025	Oshawa	8667	4581	3622	441	23	0	0	464	X	0	0	0	0	79	9
46110	Mississauga	8290	5161	2487	585	57	0	4	638	X	0	0	0	0	94	14
GTA Average		**8453**	**5215**	**2686**	**515**	**38**	**0**	**4**	**548**	**0**	**0**	**0**	**0**	**0**	**90**	**11**
51001	Ottawa	8493	5550	2740	200	3	0	0	203	X	0	0	0	0	37	1
52020	Kingston	8610	5112	2960	503	35	0	0	538	X	X	X	X	X	78	7
56051	Cornwall	8760	4483	3776	480	21	0	2	496	3	0	0	0	0	88	4
Eastern Average		**8621**	**5048**	**3159**	**394**	**20**	**0**	**1**	**412**	**1**	**0**	**0**	**0**	**0**	**68**	**4**
62200	Fort Frances	8747	3073	5345	293	36	0	1	238	90	X	X	X	X	74	17
63200	Thunder Bay	8760	4720	3921	119	0	0	2	111	6	0	0	0	0	26	0
71068	Sault Ste Marie	8760	4709	3872	166	13	0	2	155	22	0	0	X	0	41	5
75010	North Bay	8588	3595	4353	617	23	0	4	636	X	X	X	X	X	81	6
77203	Sudbury	7580	2822	4196	532	30	0	0	556	0	6	0	0	0	73	8
Northern Average		**8487**	**3784**	**4337**	**345**	**20**	**0**	**2**	**339**	**24**	**1**	**0**	**0**	**0**	**59**	**7**

X - pollutant not measured

Figure 5.1 shows composite pie diagrams of the percentages of very good to good and moderate to poor air quality recorded at sites across the province. The pie diagram on the left shows category percentages and that on the right breaks down the moderate to poor air quality slice into percentages of pollutants associated with the AQI above 31. Of the moderate to poor AQI values, 96.9 per cent were related to ozone. At all AQI sites ozone was the most frequent cause of index readings exceeding 31, ranging from 72 per cent of the exceedances at Fort Frances to 100 per cent at nine sites across the province, including Toronto Downtown. The 6.6 per cent of moderate to poor air quality in 1998, in contrast to 4.5 per cent in 1997, is due primarily to weather conditions that were more favourable for ground-level ozone formation and transport during the summer of 1998.

Although ozone was the most frequent cause of index readings over 31, the Windsor College site recorded 176 hours of index readings greater than 31 due to TRS compounds. This was the highest number of exceedances due to this pollutant at AQI sites. In the southwest region TRS compounds accounted for 5.6 per cent of AQI values greater than 31. This was due to TRS recorded mainly at Windsor College and reflects the influence of Michigan sources on the air quality measured at this site.

In the northern region, TRS levels in the moderate/poor categories accounted for 6.5 per cent of the AQI values greater than 31. However, the total number of TRS values in the moderate to poor categories recorded in the northern region, 118 hours, is less than the 188 hours recorded in southwest Ontario. The Sudbury site recorded six hours of AQI in the moderate category due to SO_2. Sarnia was the only other site that recorded AQI greater than 31 due to SO_2.

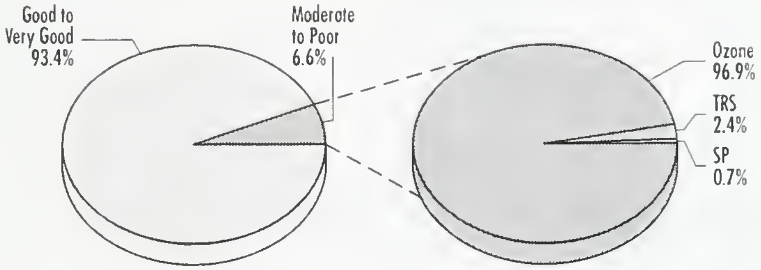
The number of days during which the AQI at each site was greater than 31 for at least one hour is also shown in Table 5.2. The number of days varied from 26 at Thunder Bay to 145 at Windsor College. Seventy-one days were recorded at Toronto Downtown, including six days having at least one hour of index values greater than 49.

Ozone was the most frequent cause of index readings over 31.

Figure 5.1

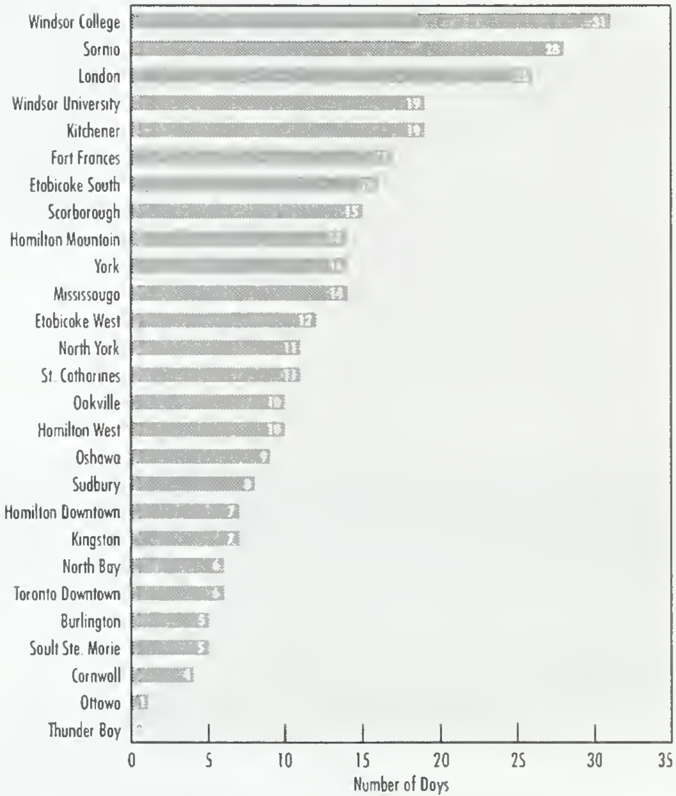
AQI Summary

(1998)



Note: API, NO_2 and CO were not responsible for any moderate to poor AQI
SO_2 was responsible for moderate to poor AQI less than 0.02% of the time.

The geographical distribution of the number of hours of AQI > 49 is shown in Figure 5.2a. The highest number of poor hours were recorded in southwest Ontario. No hours of very poor air quality were recorded at the AQI sites during 1998. The number of days of at least one hour in the poor range is shown in Figure 5.2b for all AQI sites across the province. There were no days with poor air quality (AQI > 49) recorded at the Thunder Bay site.



Note: Number at end of bar is total number of days in poor range.
AQI day has at least one hour in the poor range.

Figure 5.2b

Number of Days AQI in the Poor Range at Sites Across Ontario

(1998)

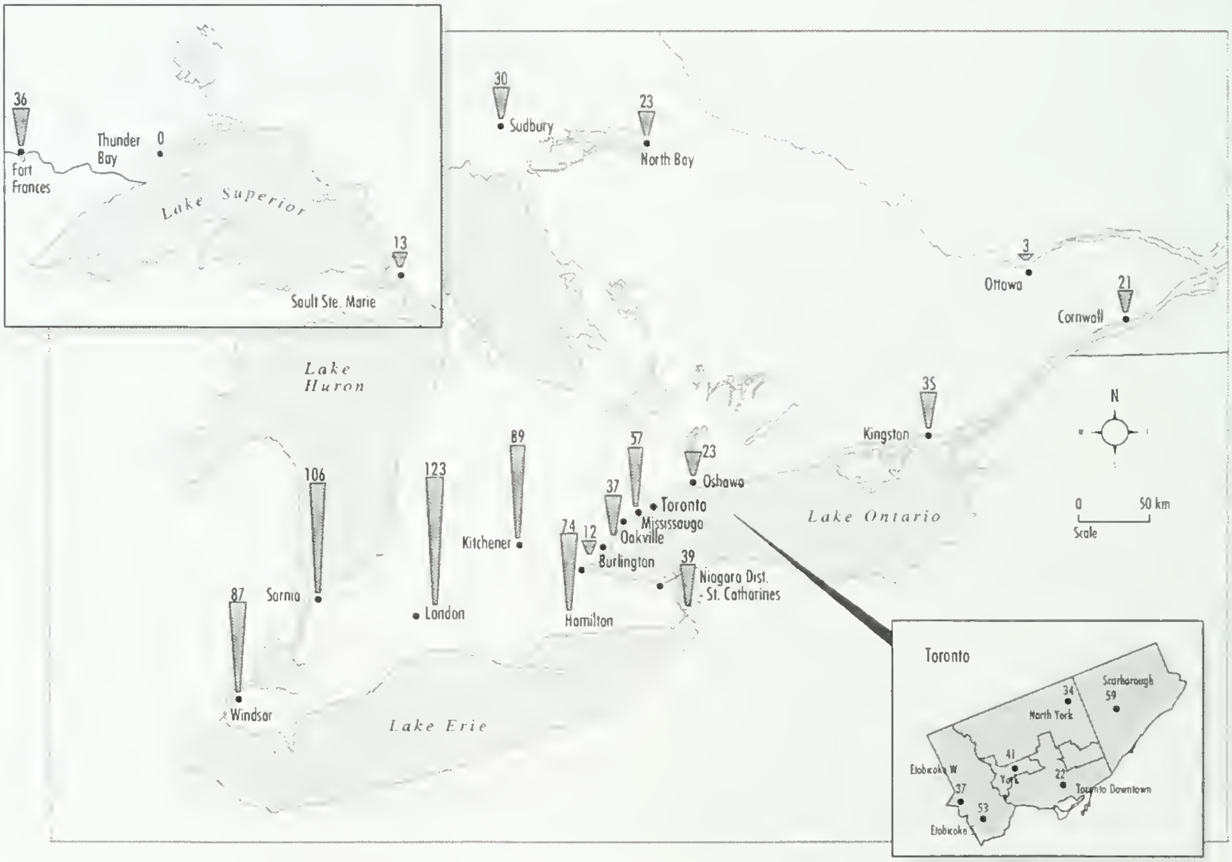


Figure 5.2a

Geographical Distribution of the Number of Hours AQI> 49 Across Ontario

(1998)

Summary statistics for each region are presented in Table 5.3 showing the percentage time the AQI was in each category and the percentage time each pollutant caused the AQI to be greater than 31. The table shows that in 1998 the southwest region had the highest percentage of time with moderate to poor air quality. The northern region had the lowest percentage of very good air quality but at the same time recorded the highest percentage of good air quality, approximately 51.1 per cent. This is due to the higher number of ozone values in the good category during the winter and spring seasons in Northern Ontario. The GTA had the highest percentage of time with very good air quality (61.7 per cent).

Regional AQI trends (1989-1998)

A 10-year trend (1989-1998) for the number of hours that the AQI was greater than 49 (in the poor category) by region is shown in Figure 5.3. The average number of days with at least one hour greater than 49 at sites in all of the regions showed a continuous decrease from 1989 to 1993. From 1993 onwards, the southwest and west central regions and the Greater Toronto Area show a large increase in the average number of days per year with the AQI greater than 49. The northern region shows a decrease and the eastern region shows a slight increase.

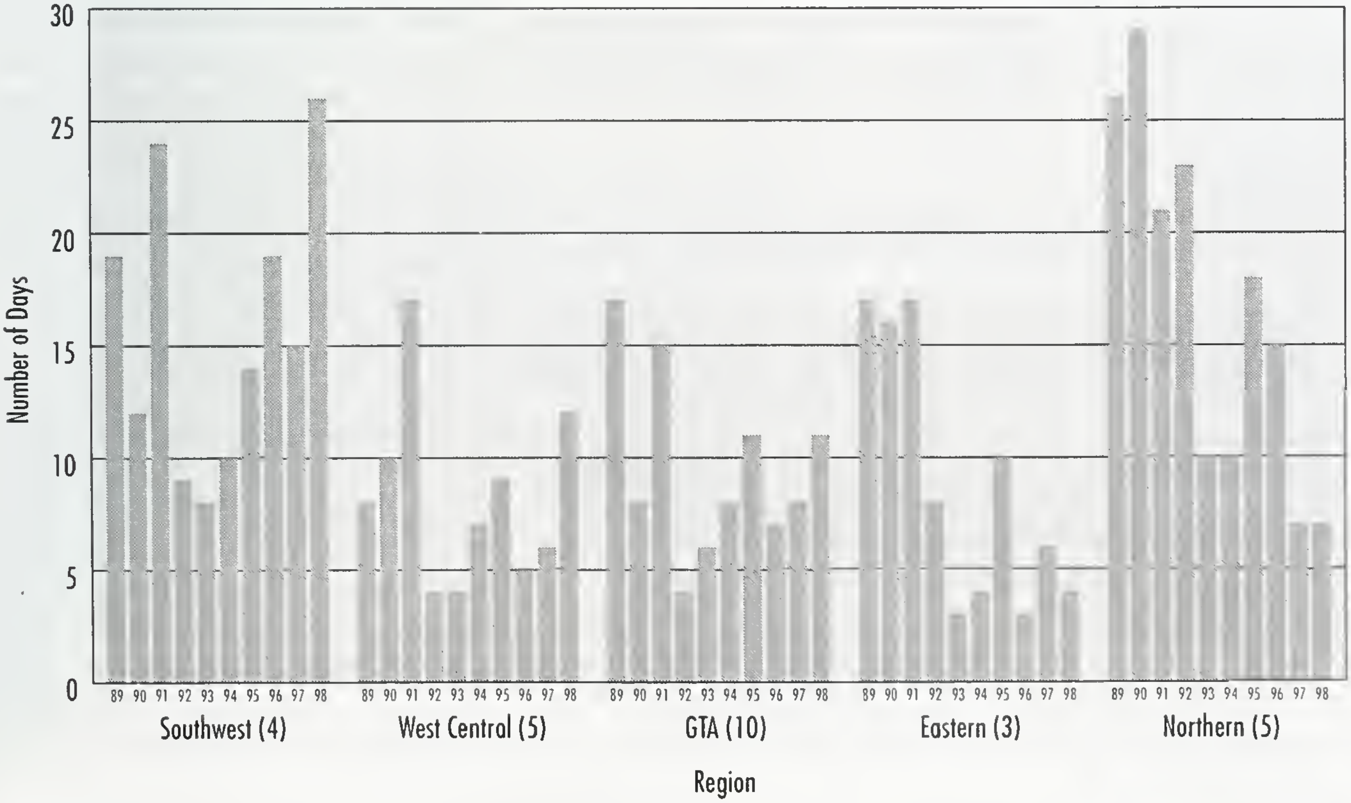
The GTA had the highest percentage of time with very good air quality.

Table 5.3
Air Quality Index Summary by Regions
(1998)

Region	% of Time AQI in Range				% Time Pollutant Responsible for AQI > 31			
	V-Good	Good	Mod.	Poor	SP	O_3	TRS	NO_2
Southwest	57.1	33.3	8.5	1.1	0.4	94.0	5.6	0.0
West Central	57.8	34.4	7.2	0.6	1.3	97.2	1.5	0.0
GTA/Central	61.7	31.8	6.1	0.4	0.6	99.3	0.1	0.0
Eastern	58.6	36.6	4.6	0.2	0.2	99.6	0.2	0.0
Northern	44.6	51.1	4.1	0.2	0.5	92.7	6.5	0.3

API, CO and NO_2 are also monitored but did not cause the AQI to be in the moderate/poor range during 1998.

Figure 5.3
Trend of the Average Number of Days AQI > 49 for Various Regions of Ontario
(1989-1998)



The air quality of the Southwest Region is affected by ozone transported into the area from bordering U.S. States.

The greatest increase was in the southwest region, which is very close to the U.S. sources of emissions that react to produce ozone. The air quality is affected by ozone transported into the area.

In 1998 there were 26 days, averaged over the four AQI sites in southwest Ontario, with at least one hour with AQI in the poor category. The previous highest number was 24 in 1991 and the smallest number was eight in 1993. The west central and southwest regions show an increase in the number of days from 1993 to 1998. The Greater Toronto Area shows a slight increasing trend since 1992, with 1998 recording 11 days. In the eastern region, the number of days decreased from 17 in 1991 to four in 1998. This is due to the reduction of concentrations of TRS compounds in Cornwall. The northern region showed no trend after 1993, with a large decrease in AQI days greater than 49 in 1997 and 1998. In Northern Ontario there has been a significant reduction of TRS levels at Fort Frances.

Air Pollution Index (1998)

There were no hours of air quality greater than 31 due to API recorded at any of the AQI sites during 1998.

Table 5.4

Monthly Mean Maximum Air Temperature and number of "hot days" with maximum temperatures above 30°C at Windsor Airport during 1997 and 1998

Year	May	June	July	August	Sept.	number of "hot days"
1997	15.9 (0)	25.2 (4)	27.0 (7)	23.9 (1)	22.0 (0)	12
1998	23.9 (5)	25.7 (11)	28.4 (9)	27.5 (6)	25.8 (6)	37

'hot day' is a day with air temperature greater than 30°C
number in brackets are the number of "hot days"

Weather and air quality during 1998

AQI readings in the poor category increased from 726 hours in 1997 to 1186 hours in 1998. This increase can be attributed to conducive weather conditions that produced higher ground-level ozone concentrations during the summer of 1998. The number of AQI readings greater than 49 due to ozone increased from 670 in 1997 to 1168 in 1998.

To demonstrate the importance of meteorology in the production of ozone and concentrations measured in the province, data from the Environment Canada meteorological site in Windsor were analysed with emphasis being placed on the number of "hot days" (those with maximum temperatures above 30 degrees C).

Table 5.4 shows monthly mean maximum temperatures and number of days with mean temperatures above 30 degrees C (in brackets) at Windsor Airport in southern Ontario for the months May to September in 1997 and 1998. In 1998 monthly average maximum temperatures during the months of May to September were all higher than in the corresponding months of 1997. In fact the 1998 mean maximum temperature during May was 8 degrees C higher than in 1997. The number of "hot days" during each month was significantly higher in 1998 at the Windsor site than in 1997. A total of 12 "hot days" were recorded in Windsor from May to September during 1997, and 37 such days during 1998. Although there was a significant increase in the number of "hot days" in 1998, there was no corresponding increase in the number of AQI greater than 31 due to ozone. High ozone concentrations are controlled by a number of factors and very hot temperature is just one of them. Wind direction, wind speed, amount of incoming radiation (sunshine) and emissions are also important.

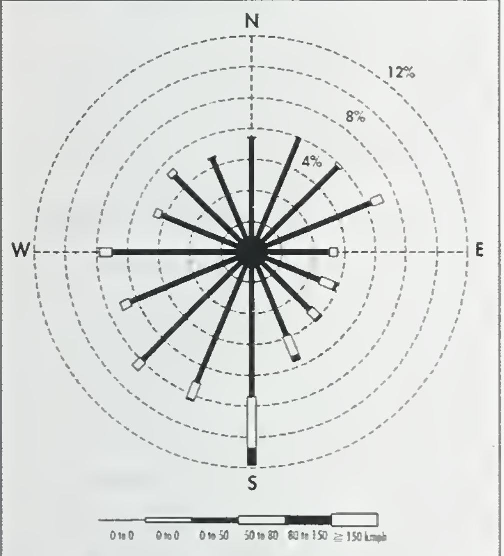
Pollution roses, ozone concentrations versus wind direction, are shown in Figures 5.4a and 5.4b for Windsor University for May to September during 1997 and 1998. The pollution rose shows the frequency of occurrence of ozone concentrations in the 0-50, 50-80 and greater than 80 ppb ranges for each wind direction. Transport of air pollutants depends on wind flow, and the pollution roses graphically identify the directions from which ozone is transported into the area. In 1997 Windsor's ozone levels greater than 80 ppb were associated with southerly wind flows. Similar concentrations in 1998 were associated with winds from the west-southwest to east- southeast sectors. This shows the influence of emissions from U.S. states to the southwest and south of the lower Great Lakes on the air quality of southern Ontario.

Figure 5.5 shows the percentage of good to very good air quality as measured at AQI sites across Ontario from 1989 to 1998. Note that the air quality was 96.2 per cent in the good/very good categories in 1992 compared to 93.3 per cent in 1991. The increase in good air quality measured in 1992 was due to a lack of meteorological conditions conducive for ozone formation. For example, Windsor in 1991 recorded 41 "hot days" and in 1992 only two such days. Accordingly, the air quality in the very good to good categories increased from 93.3 per cent in 1991 to 96.4 per cent in 1992. The year-to-year variability in ozone exceedances was discussed previously in Chapter 2.

Transport of air pollutants depends on wind flow.

Figure 5.4a

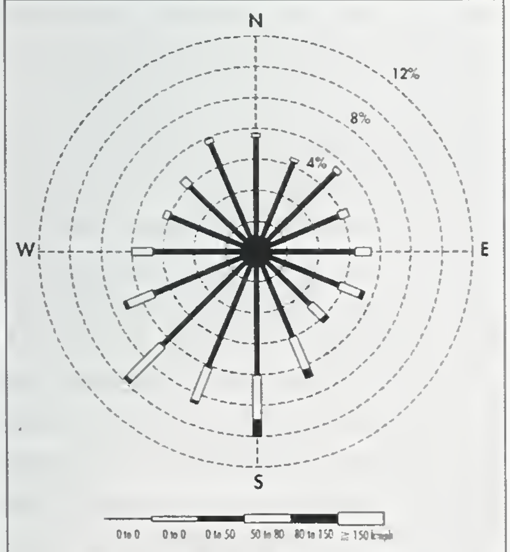
Ozone Pollution Rose for Windsor May 1, 1997 through September 30, 1997



Note: Level: 10 m; Winds: Direction; Number of Records Used: 3618

Figure 5.4b

Ozone Pollution Rose for Windsor May 1, 1998 through September 30, 1998

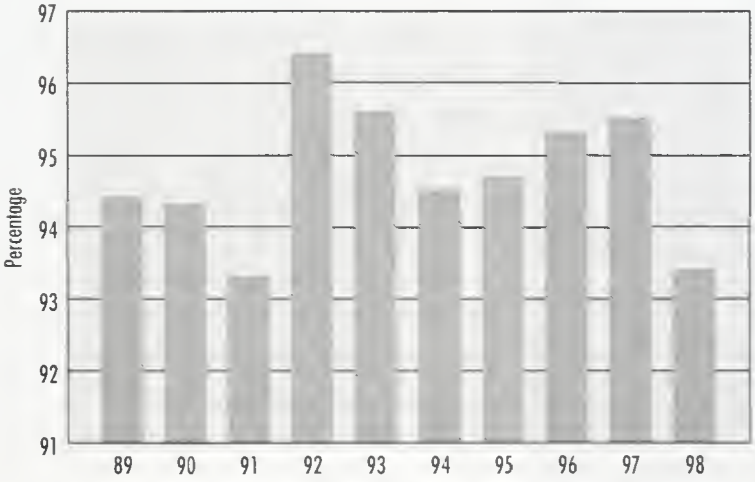


Note: Level: 10 m; Winds: Direction; Number of Records Used: 3541

Figure 5.5

Ten Year Trend of Good to Very Good Air Quality at Sites Across Ontario

(1989-1998)



CHAPTER 6

Regional Smog Episodes

Pollutants associated with various air issues are often transported by large-scale weather systems.

THE GENERATION, BUILDUP AND DISSIPATION OF SMOG over eastern North America are strongly influenced by synoptic-scale weather systems. In particular, pollutants associated with various air issues (e.g. acid species, ground-level ozone and its precursors, fine particles and persistent organic pollutants) are often transported by large-scale weather systems up to thousands of kilometres from their point of origin before being deposited or impacting on receptors. Thus, long-range transport and trans-boundary flow of air pollutants have a significant role in air quality considerations on a regional scale.

For southern Ontario, this is particularly evident for ozone during late spring and summer. Elevated ozone is then primarily a component of photochemical smog in which nitrogen oxides and hydrocarbons (volatile organic compounds), precursors of ozone, react in the air in the presence of sunlight. The ozone tends to be formed downwind of precursor sources and is thus capable of traveling long distances through the atmosphere. As a result, ozone is often a manifestation of long-range transport and trans-boundary flow of air pollution.

Episodes of elevated ozone at ground level usually occur between May and September, and are associated with high pressure weather systems that typically move out of Central Canada into the U.S. midwest or the Great Lakes area and then eastward to the Atlantic coast. The frequency of these episodes varies from year to year and depends on large-scale weather patterns and meteorological factors.

Episodes in southern Ontario are often a part of a regional condition that prevails over much of northeastern North America. For southern Ontario, it is a significant trans-boundary problem because elevated pollution levels are often due to weather patterns that affect the lower Great Lakes region, resulting in the long-range transport of ozone and its precursors from neighbouring U.S. industrial states. Ontario often shares a common airshed with several neighbouring states, hence emissions in one source area can affect air quality in the whole airshed.

Figure 6.1 illustrates a generalized synoptic weather pattern over southern Ontario during high smog conditions. The back portion of a slow-moving high-pressure system generally has winds with a southerly component that has travelled

CLEAN AIR TIP

Turn off unnecessary lights and appliances, since electricity generation contributes to smog.

Southerly flow is conducive to smog episodes over Southern Ontario.

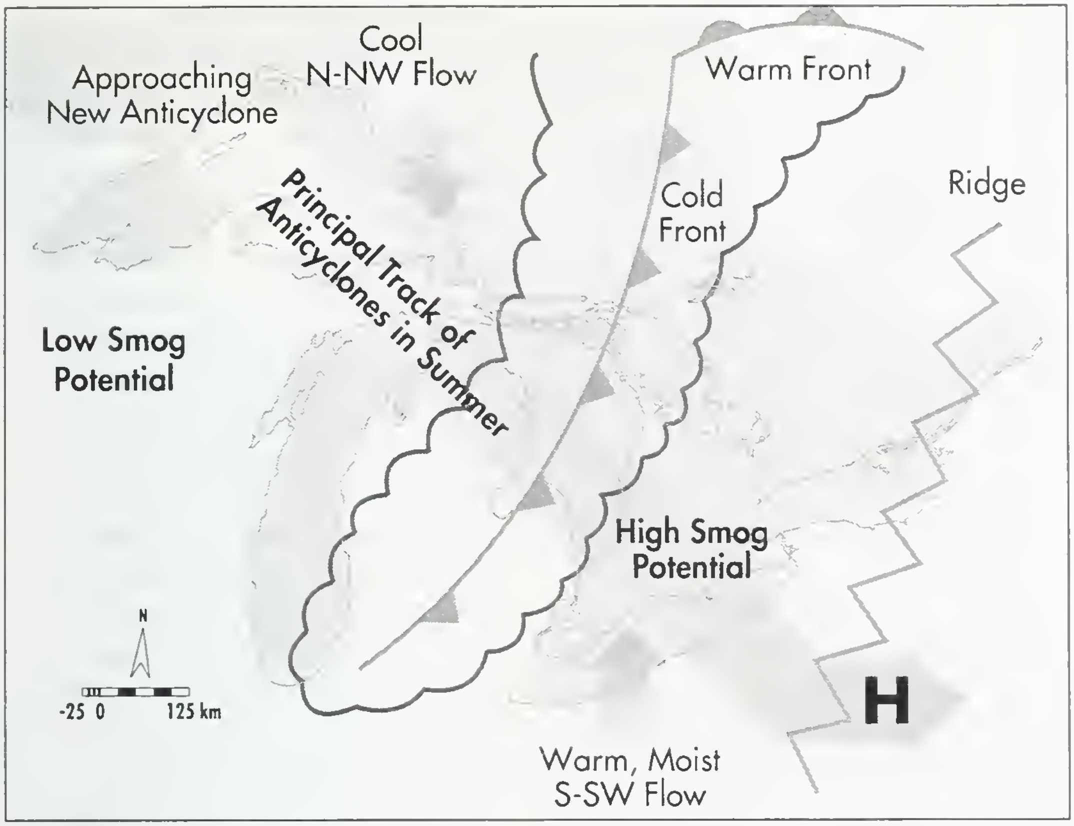


Figure 6.1
Generalized Synoptic Weather Pattern Over Southern Ontario Conducive to Elevated Pollutant Levels

over major precursor source areas located in the midwest and eastern United States.

As the high pressure moves west to east, precursors are emitted into the front of the system and circulate to the rear over a period of two to six days, depending on the wind speed. This results in the accumulation of a number of pollutants (both primary and secondary species) in the air mass. Thus, south to southwesterly flow on the rear side of a high-pressure cell provides favourable conditions for transport of pollution and is conducive to episodes of smog (fine particles and ozone) over southern Ontario.

Summer 1998

The summer of 1998 was characterized by five multi-day ozone episodes across southern Ontario. Of these, widespread elevated ozone levels persisting for three or more consecutive days prompted the ministry to issue air quality advisories for May 14-16, June 23-25 and July 13-16.

The first episode, May 14-16, was the earliest documented episode in the smog season since 1993 when the air quality advisory program began. Sunny and hot conditions with a light south to southwesterly flow dominated the region. This allowed the transport, trans-boundary flow and accumulation of ozone and its precursors over southern Ontario. Maximum one-hour ozone levels reached 120 ppb on May 14 (Sarnia), 140 ppb on May 15 (York) and 108 ppb on May 16 (Dorset). On May 15, 29 sites exceeded the one-hour Ontario criterion of 80 ppb, from Windsor to Stouffville in the south to Sault Ste. Marie in the north. Daily fine particle ($PM_{2.5}$) levels during pre- and post-episode days were typically 12-15 $\mu g/m^3$ and close to 50 $\mu g/m^3$ on May 15 and May 16 across southern Ontario.

The second episode, June 23-25, was characterized by sunny, hot and humid conditions coupled with west to southwest winds and resulted in elevated air pollu-

NO_x and VOC from U.S. and Ontario sources react in sunlight to form smog.

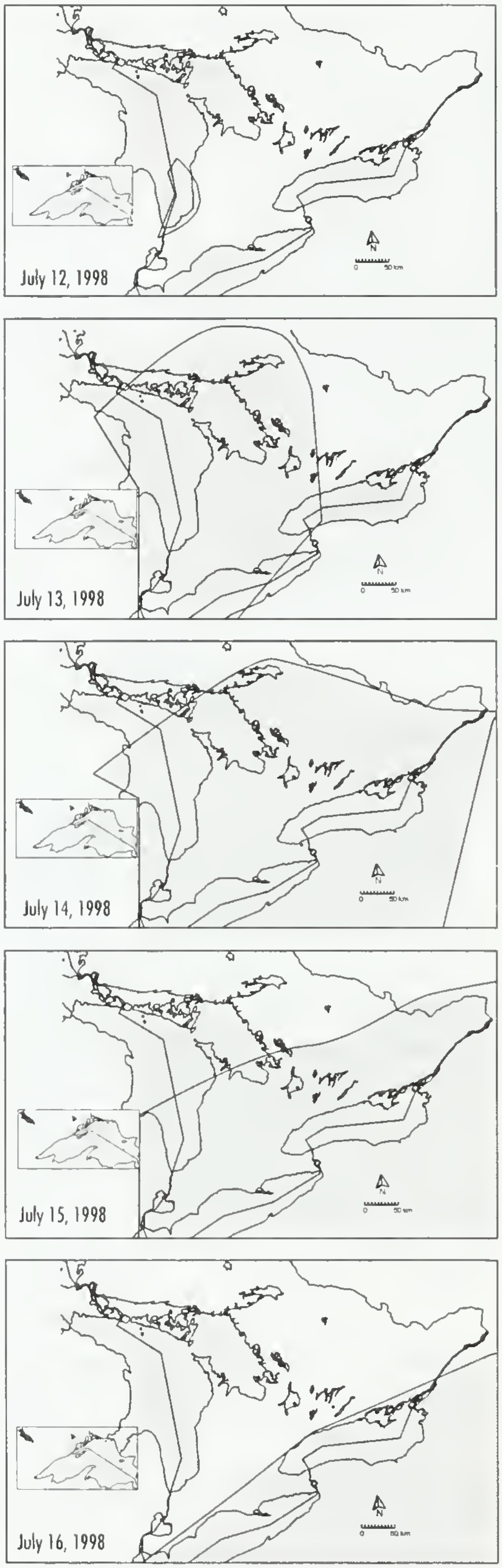


Figure 6.2

Space-time chronology of the July 13-16 ozone episode over Ontario

1 hour ozone maximum exceeds the Ontario criterion of 80 ppb in the enclosed area.

tion due to ground-level ozone across southern Ontario. Maximum one-hour ozone levels reached 100 ppb on June 23 (Windsor), 129 ppb on June 24 (Grand Bend) and 137 ppb on June 25 (Kitchener). This episode was not as extensive as the May event and was confined to southern Ontario, from Windsor to the Greater Toronto Area. On both June 24 and June 25, 14 sites exceeded the one-hour Ontario criterion of 80 ppb. Daily fine particle ($PM_{2.5}$) levels during this episode reached about 40 µg/m^3 across southern Ontario on June 25.

The third episode, July 13-16, persisted for four days over the region. It was also characterized by sunny and hot conditions with light southwest flows. These conditions allowed nitrogen oxides and volatile organic compounds from the U.S. and Ontario sources to react in sunlight to form photochemical smog. This allowed the accumulation of a number of pollutants, both primary and secondary species, in the air mass over a number of days. For instance, in south-central Ontario concentrations of highly reactive volatile organic compounds like ethane, propane and isoprene typically increased three to 10 times above background levels during this episode. Maximum one-hour ozone levels reached 100 ppb on July 13 (Long Point), 138 ppb on July 14 (Grand Bend), 120 ppb on July 15 (Grand Bend) and 87 ppb on July 16 (North York and Scarborough). Twenty-two sites exceeded the one-hour Ontario criterion of 80 ppb over large areas of the province on July 13, 28 sites on July 14 and 26 sites on July 15.

A space-time chronology of the third ozone episode is shown in Figure 6.2. Elevated ozone levels first appeared over southwestern Ontario on July 12 and were confined to areas just east of Lake Huron. By July 13, ozone exceedances covered southwestern Ontario and the Greater Toronto Area and extended northwards to include both Sudbury and North Bay. The elevated ozone levels persisted through July 14 and July 15 over all of southern Ontario and pushed northeastward to affect the Ottawa region on July 15. A weak cold front on July 16 moved across the region by evening and allowed a shift of winds into the northwest, which brought relief with a cooler, less humid and cleaner air mass. Only a few ozone exceedances occurred on July 16, and these were confined to the north shores of Lake Erie and Lake Ontario. Daily fine particle ($PM_{2.5}$) levels during pre- and post episode days were typically 12-15 µg/m^3 and during the episode reached about 45 µg/m^3 across southern Ontario, a three- to four-fold increase.

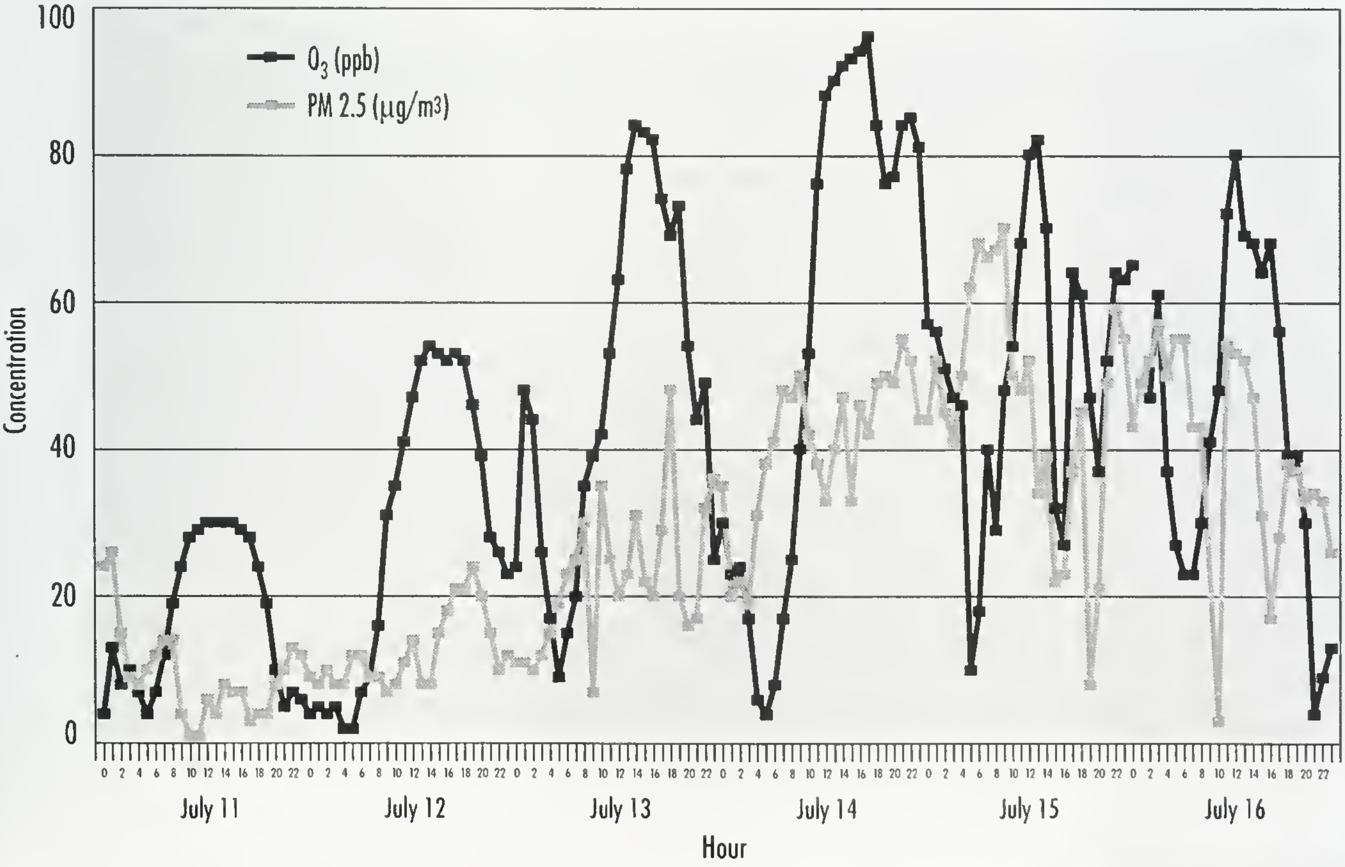
Diurnal variations of ozone and fine particle concentrations for the episode at the Etobicoke South site in Toronto are shown in Figure 6.3. The peak ozone level (96 ppb) was recorded on July 14 and the highest daily $PM_{2.5}$ level (46 µg/m^3) occurred the next day as the air mass aged.

Winter 1998

A fine particle episode occurred Feb. 9-11, 1998. Preliminary evidence indicate that it was widespread across southern Ontario and southern Quebec, and that it was largely the result of stagnating weather conditions and the accumulation of local emissions in the air mass. Daily fine particle ($PM_{2.5}$) levels during the episode reached about 40 µg/m^3 across southern Ontario in urban centres and about 20-25 µg/m^3 in rural areas. In the Greater Toronto Area, daily $PM_{2.5}$ levels during the episode were typically 20-25 µg/m^3. Pre- and post-episode days were near 10 µg/m^3. Winter fine particle episodes have been documented only recently, owing to the establishment of the ministry's new real time fine particle monitoring network

Fine particles are elevated during winter smog episodes.

Figure 6.3
Ozone and $PM_{2.5}$ at Etobicoke South, July 11-16, 1998



CHAPTER 7

International Air Quality Perspective

Ontario has made significant reductions to key air pollutants.

HOW DOES TORONTO'S AIR QUALITY MEASURE UP?

The purpose of this section is to compare air quality levels in Toronto with those measured elsewhere in Canada and in the rest of the world. To do this, in early 1999 the Ontario Ministry of the Environment requested ambient air quality data from 93 cities in some 65 countries worldwide. Thirty-one cities responded with air quality data that could be used in a comparison with Toronto's. Their metropolitan populations ranged from about 0.1 million (Halifax) to 20 million (Mexico City).

Data from all available monitoring sites within the metropolitan areas of each city were requested because it was felt that this would be more representative of average city air quality than data from a select number of sites. It should be pointed out that monitoring methods and siting procedures may vary from country to country; therefore comparisons among nations are subject to caution. Since the form of air quality standards may vary as well, the inter-city comparisons presented here are referenced to ambient air quality criteria (AAQC) for Ontario and the national ambient air quality standards (NAAQS) for the United States. For the most recent available reporting year, 1997, levels of the criteria pollutants, including O_3, PM_{10}, NO_2, CO and SO_2, will be compared worldwide. As noted in previous sections of this report, Ontario has made significant reductions to key air pollutants, but smog remains a major concern. Since ozone and inhalable particles are the two main components of smog, their results will be presented not only for 1997, but for the 10-year period 1988 to 1997, as well.

CLEAN AIR TIP

Turn the air conditioner down or off, since increased use of electricity leads to higher smog levels.

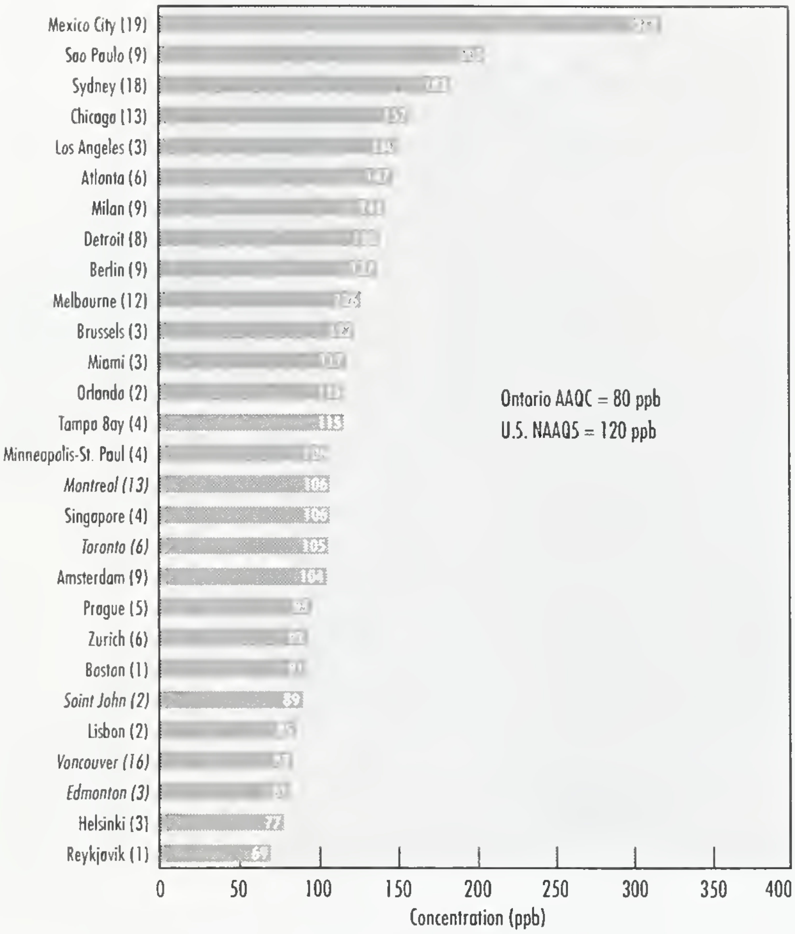
Ozone results: Maximum one-hour ozone levels for 1997 are displayed for 28 cities in Figure 7.1. The highest one-hour concentration during 1997 was recorded in Mexico City (318 ppb), followed by Sao Paulo (205 ppb) and Sydney (183 ppb). Of the 28 cities reporting, 11 exceeded the U.S. NAAQS (120 ppb) and 26 cities exceeded the more restrictive Ontario one-hour AAQC (80 ppb). Toronto ranked 11th best of 28 cities in maximum one-hour ozone concentrations during 1997. It should be re-emphasized here that hourly ozone concentrations vary from year to year depending on weather conditions.

The nine year range in maximum ozone concentration for 19 cities is shown in Figure 7.2. During that nine years, three neighbouring U.S. cities, namely Detroit, Chicago and New York, recorded higher ozone levels than Toronto. Of the three Canadian cities shown, Toronto recorded the highest mean maximum ozone level, followed by Montreal and Vancouver.

Figure 7.1

Maximum 1-Hour Ozone Concentrations in Selected World Cities

(1997)



Note: Figure in brackets denotes number of monitoring sites used.

Figure 7.2

Range of Maximum 1-Hour Ozone Levels in Selected World Cities

(1988-1997)

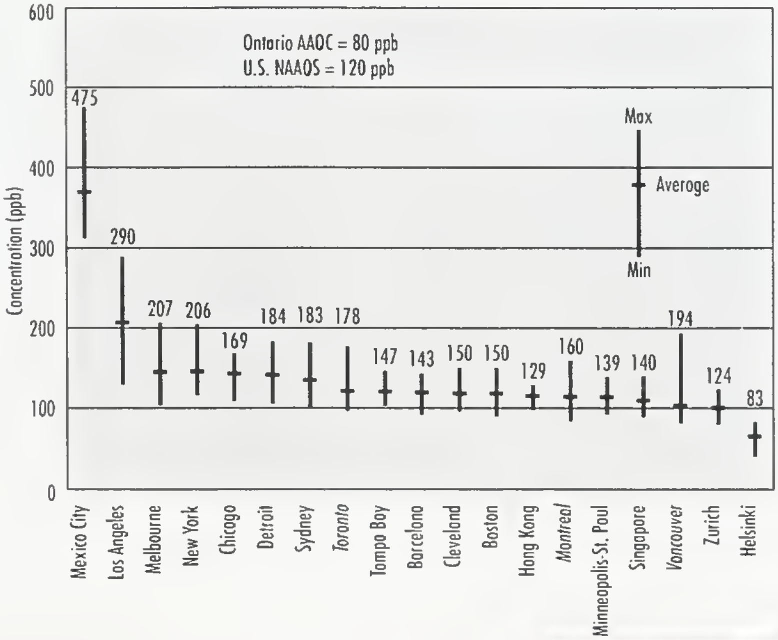
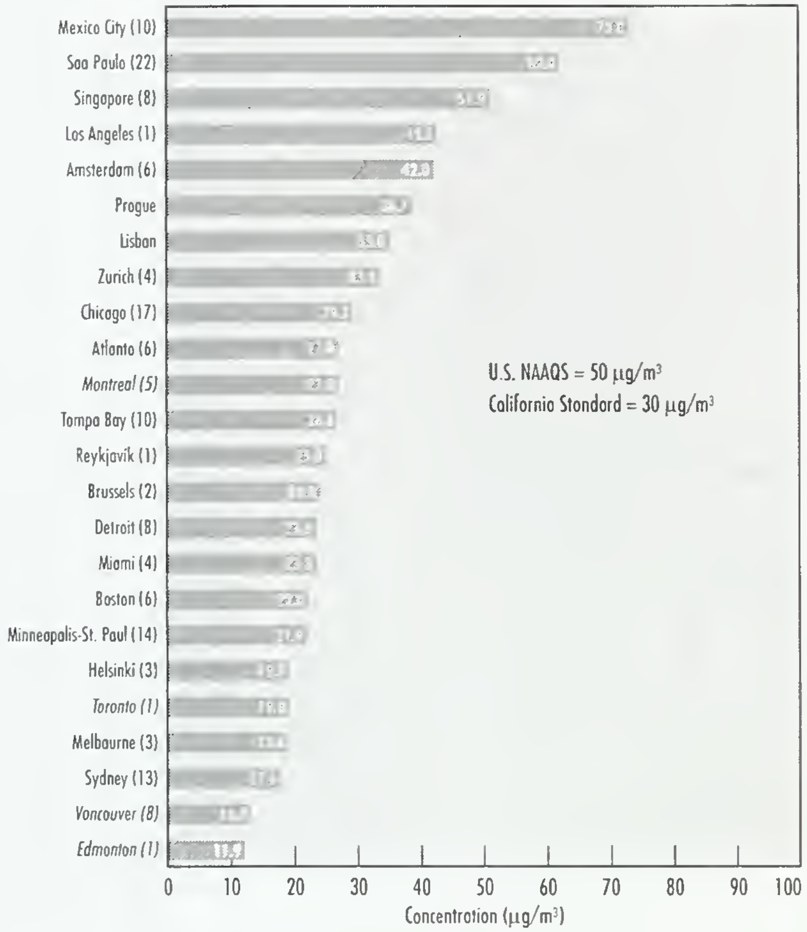


Figure 7.3

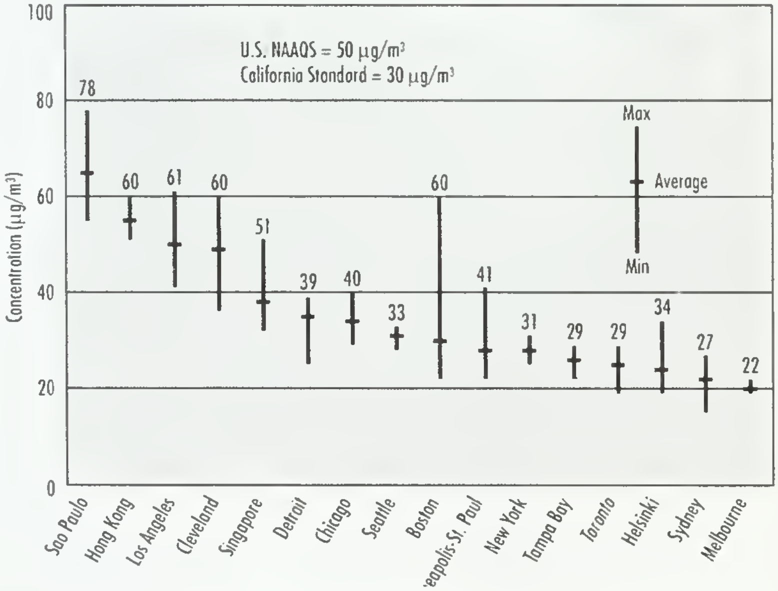
Annual Mean PM_{10} in Selected World Cities (1997)



Note: Figure in brackets denotes number of monitoring sites used.

Figure 7.4

Range of 24-Hour PM_{10} Annual Means in World Cities (1989-1997)



Inhalable particle results: Mean annual PM_{10} levels for 1997 are displayed in Figure 7.3. The highest annual mean was recorded in Mexico City (73 µg/m³), followed by Sao Paulo (62 µg/m³) and Singapore (51 µg/m³). Of the 24 cities reporting, only three exceeded the U.S. NAAQS (50 µg/m³) and eight exceeded the more restrictive California standard (30 µg/m³). Toronto ranked fifth best when it comes to mean annual PM_{10} levels during 1997.

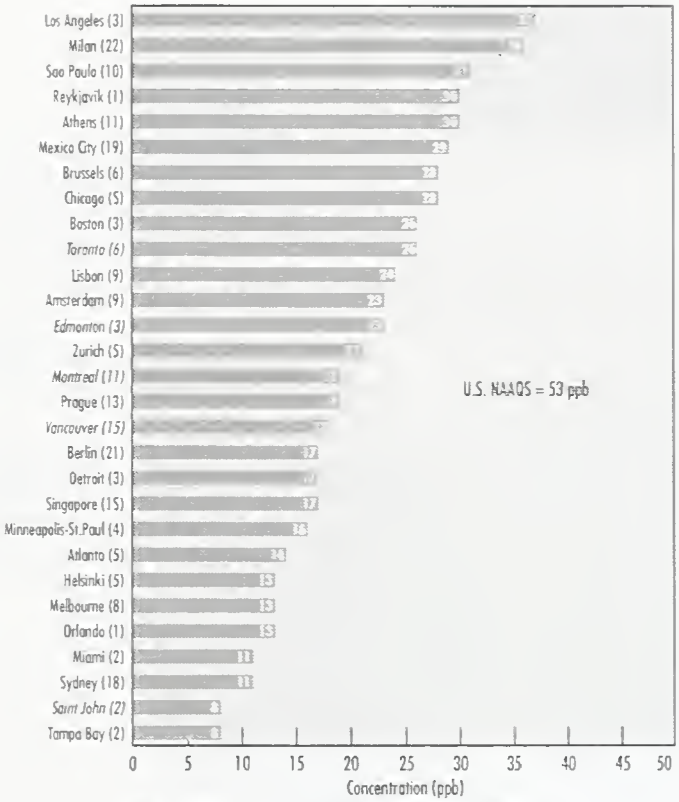
The nine year range in mean annual PM_{10} levels is shown in Figure 7.4. Toronto is one of four cities that never exceeded the U.S. NAAQS or California standard during those nine years. Toronto's PM_{10} levels were at the lower end of the cities reporting. Neighbouring U.S. cities, including Detroit, Chicago, New York and Cleveland, recorded higher PM_{10} levels than Toronto.

Nitrogen dioxide results: The mean annual NO_2 levels for 1997 are shown for 29 cities in Figure 7.5. Toronto ranked 20th of the 29 cities in nitrogen dioxide levels. Los Angeles, Milan and Sao Paulo were at the higher end of the annual means, while Tampa Bay and Saint John were at the lower end. Elevated NO_2 levels in major cities are attributed to motor vehicle emissions.

Carbon monoxide results: Toronto ranked 12th best of 28 world cities for one-hour maximum CO levels during 1997 (Figure 7.6). Toronto's carbon monoxide levels were lower than those of other Canadian cities, such as Montreal, Edmonton, Vancouver and Saint John. The highest levels were measured in Mexico City, the only city to exceed the one-hour Ontario AAQC and U.S. NAAQS for CO.

Figure 7.5

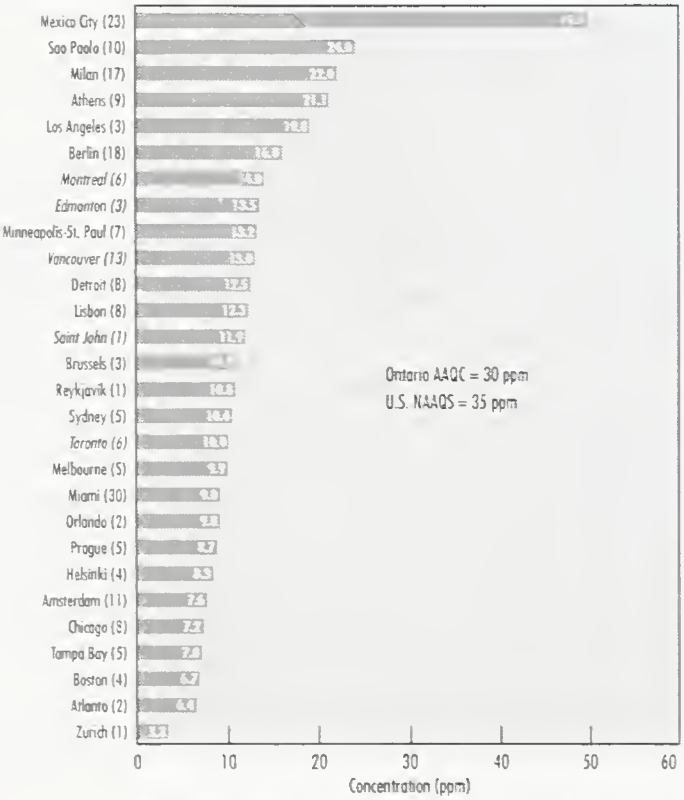
Annual Mean Nitrogen Dioxide Concentrations in Selected World Cities (1997)



Note: Figure in brockets denotes number of monitoring sites used.

Figure 7.6

Maximum 1-Hour Carbon Monoxide Concentrations in Selected World Cities (1997)



Note: Figure in brockets denotes number of monitoring sites used.

Toronto's air quality was better than that in most of the international cities with which it was compared.

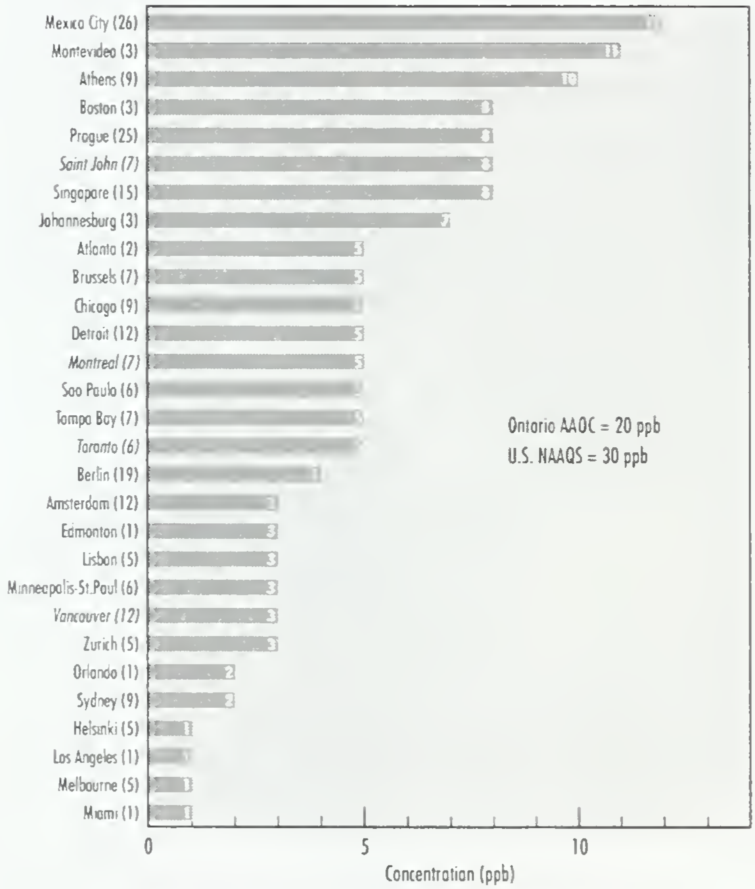
Sulphur dioxide results: For mean annual SO_2 levels, Toronto tied for 14th best of 29 cities compared during 1997 (Figure 7.7). The worst cities for sulphur dioxide were Mexico City, Montevideo and Athens, and the best were Miami, Melbourne, Los Angeles and Helsinki. Toronto's SO_2 levels were similar to those of Montreal and lower than those of Saint John.

Summary: Overall, using the most recent available data (1997), Toronto's air quality was better than that in most of the international cities with which it was compared. Data analysis strongly suggests that neighbouring U.S. states are significant contributors to elevated levels of ozone and fine particles in southern Ontario, including Toronto.

Figure 7.7

Annual Mean Sulphur Dioxide Concentrations in Selected World Cities

(1997)



Note: Figure in brackets denotes number of monitoring sites used.

There has been consistent improvement in the province's air quality.

Future Directions

CHAPTER 8

SINCE THE FIRST EDITION OF THIS REPORT IN 1971, there has been consistent improvement in the province's air quality, even as the population has grown. For example, significant decreases have been achieved for sulphur dioxide, carbon monoxide, total suspended particulate matter, nitrogen oxides and total reduced sulphur compound levels.

Encouraging as this is, there is still a great deal of work to be done, and the Ontario government is directing increased emphasis to ozone and inhalable and respirable particles (PM_{10} and $PM_{2.5}$), which recent scientific evidence suggests have significant health effects.

Ground-level ozone remains a concern, as does particulate matter. In 1998 there were a number of days on which PM_{10} levels exceeded the Ontario 24-hour interim PM_{10} criterion of 50 µg/m^3. For ambient urban sites the highest percentage of days (10 per cent) occurred in Windsor, a city strongly influenced by long-range transport and trans-boundary effect.

Data analysis strongly implicates neighbouring U.S. states – namely, Ohio, Michigan, Illinois and New York – as significant contributors to high levels of fine particles and ozone in southern Ontario. The contributions from long-range transport and trans-boundary movement of air pollution and from local sources need further assessment.

Because of the potential health and environmental effects of these two key ingredients of smog, continued monitoring is required to evaluate trends and determine the effectiveness of reduction and abatement strategies.

Ontario has begun to change its existing monitoring network by deploying real-time monitors of inhalable and respirable particles. These are being phased in over the next few years. In 1998 there were 18 monitors of $PM_{10}/PM_{2.5}$ for which sufficient data were available. The collection and assessment of such data will allow future improvements to the Air Quality Index (AQI) and air quality advisory programs by including fine particle measurements as a key element, along with ozone, in the AQI monitoring network.

The Ontario government has committed itself fully to improving air quality with a series of initiatives. Foremost of these is its Drive Clean program, which started in spring 1999 and required emission testing of light-duty vehicles, followed by repairs where necessary. In January of 2000, the ministry launched its new heavy-duty vehicle emissions testing program

CLEAN AIR TIP

Don't light up on Smog Alert days: whether it's lighting up your gas barbecue or a campfire, the extra smoke will only make poor air quality worse.

These government initiatives will go a long way toward improving the quality of Ontario's air.

to reduce emissions from trucks, buses and other heavy duty vehicles.

Other ongoing activities include:

- Ontario's Anti-Smog Action Plan, a government-industry partnership that commits 44 organizations to reduction of smog-causing emissions
- updated air quality standards and regulations to make them better, clearer and stronger, including standards for fine particles
- less polluting blends of gasoline mandated during the summer – resulting in 18,000 fewer tonnes of smog-causing compounds annually
- strong environmental protection measures being built into the design of a competitive electricity market
- $3 million spent since 1998 on the province's air monitoring network, as well as another $2 million for new mobile air monitoring platforms
- public education, which includes Partners-in-Air for high school students to learn about air pollution and meteorology
- an ongoing campaign to persuade neighbouring U.S. states to toughen their air quality regulations – which would lessen trans-boundary pollution.

Along with the contributions of concerned citizens, organizations and industries, these initiatives will go a long way toward improving the quality of Ontario's air.

Glossary

Acidic deposition refers to deposition of a variety of acidic pollutants (acids or acid- forming substances such as sulphates and nitrates) on biota or land or in waters of the earth's surface.

Air quality advisory an alert issued to the public when elevated pollution levels are forecast due to ground-level ozone.

Air Quality Index real-time information system that provides the public with an indication of air quality in major cities across Ontario.

AQI station continuous data monitoring station in a built up area. Data used to inform the public of air quality levels on a real-time basis; station must report on at least ozone and suspended particles to be classified AQI.

Air Pollution Index basis of Ontario's alert and control system to warn of deteriorating air quality; derived from 24-hour running averages of sulphur dioxide and suspended particles.

Ambient air outdoor or open air.

Carcinogen an agent that incites carcinoma (cancer) or other malignancy.

Continuous pollutant contaminant for which a continuous record exists; effectively, pollutants that have hourly data (maximum 8760 values per non-leap year).

Continuous station where pollutants are measured on a real-time basis and data determined hourly (as for ozone, sulphur dioxide).

Criterion maximum concentration or level (based on potential effects) of contaminant that is desirable or considered acceptable in ambient air.

Daily pollutant contaminant with a 24-hour or daily value (maximum 365 values per non-leap year).

Detection limit minimum concentration of a contaminant that can be determined.

Fossil fuels natural gas, petroleum, coal and any form of solid, liquid or gaseous fuel derived from such materials for the purpose of creating heat.

Geometric mean statistic of a data set calculated by taking the nth root of the product of all (n) values in a data set. Provides a better indication than arithmetic mean of the central tendency for a small data set with extreme values.

Global warming long-term rise in the average temperature of the earth; principally due to an increase in the buildup of carbon dioxide and other gases.

Ground-level ozone colourless gas formed from chemical reactions between nitrogen oxide and hydrocarbons in the presence of sunlight near the earth's surface.

Inhalable particles represents up to 60 per cent of the total suspended particulate matter; composed of both primary (diameter 2.6 to 10.0 microns) and fine (diameter < 2.5 microns) particles; also referred to as PM_{10}.

Micron a millionth of a metre; symbol µm.

Median middle value of a set of numbers arranged in order of magnitude.

Monthly pollutant contaminant for which there exists only a monthly (30-day) value (maximum 12 values per year).

Non-continuous station station that measures pollutant concentration on a daily, six-day frequency or monthly cycle (as for total suspended particulate matter).

Ozone episode day a day on which widespread (hundreds of kilometres) elevated ozone levels (greater than 80 ppb maximum hourly concentration) occur simultaneously.

Particulate matter refers to any airborne finely divided solid or liquid material with an aerodynamic diameter smaller than 100 microns.

Percentile value percentage of the data set that lies below the stated value; if the 70 percentile value is 0.10 ppm, then 70 per cent of the data are equal to or below 0.10 ppm.

Photochemical oxidant any of the chemicals that enter into oxidation reactions in the presence of light or other radiant energy.

Photochemical reaction chemical reaction influenced or initiated by light, particularly ultraviolet light.

Photochemical smog see smog.

Primary pollutant contaminant emitted directly to the atmosphere.

Respirable particles particles smaller than about 2.5 microns in diameter, which arise mainly from condensation of hot vapours and chemically driven gas to particle conversion processes; also referred to as $PM_{2.5}$. These are fine enough to penetrate deeply into the lungs and have the greatest effects on health.

Secondary pollutant contaminant formed from other pollutants in the atmosphere.

Smog a contraction of smoke and fog; colloquial term used for photochemical fog, which includes ozone and other contaminants; tends to be a brownish haze.

Stratosphere atmosphere 10 to 40 kilometres above the earth's surface.

Stratospheric ozone ozone formed in the stratosphere from the conversion of oxygen molecules by solar radiation; ozone found there absorbs much ultraviolet radiation and prevents it from reaching the earth.

Suspended particles suspended particulate matter most likely to reach the lungs (diameter less than 5-10 microns).

Total suspended particulate matter generic term for airborne particles including smoke, fume, dust, fly ash and pollen; approximately 0.1 to 100 microns in diameter.

Toxic deposition absorption or adsorption of a toxic pollutant at ground, vegetative or surface levels.

Toxic pollutant substance that can cause cancer, genetic mutations, organ damage, changes to the nervous system, or even physiological harm as a result of prolonged exposure, even to relatively small amounts.

Troposphere atmospheric layer extending about 10 kilometres above the earth's surface.

Abbreviations

AAQC	ambient air quality criteria (Ontario)
API	air pollution index
AQI	Air Quality Index
AQUIS	air quality information system
CO	carbon monoxide
CO_2	carbon dioxide
COH	coefficient of haze reported as SP
EC	Environment Canada
EMRB	Environmental Monitoring and Reporting Branch
EST	Eastern Standard Time
H2S	hydrogen sulphide
INS	insufficient data to calculate statistic
IP	inhalable particles
LIMA	Lambton industry meteorological alert
MOE	Ministry of the Environment
NAAQS	national ambient air quality standard (U.S.)
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
$PM_{2.5}$	particles less than 2.5 microns
PM_{10}	particles less than 10 microns
RP	respirable particles
SO_2	sulphur dioxide
SO_x	sulphur oxides
SP	suspended particles
TEOM	Tapered Element Oscillating Microbalance
TRS	total reduced sulphur
TSP	total suspended particles
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
kg	kilogram
kt	kilotonne
$\mu g/m^3$	micrograms (of contaminant) per cubic metre (of air)
ppb	parts (of contaminant) per billion (parts of air)
ppm	parts (of contaminant) per million (parts of air)

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